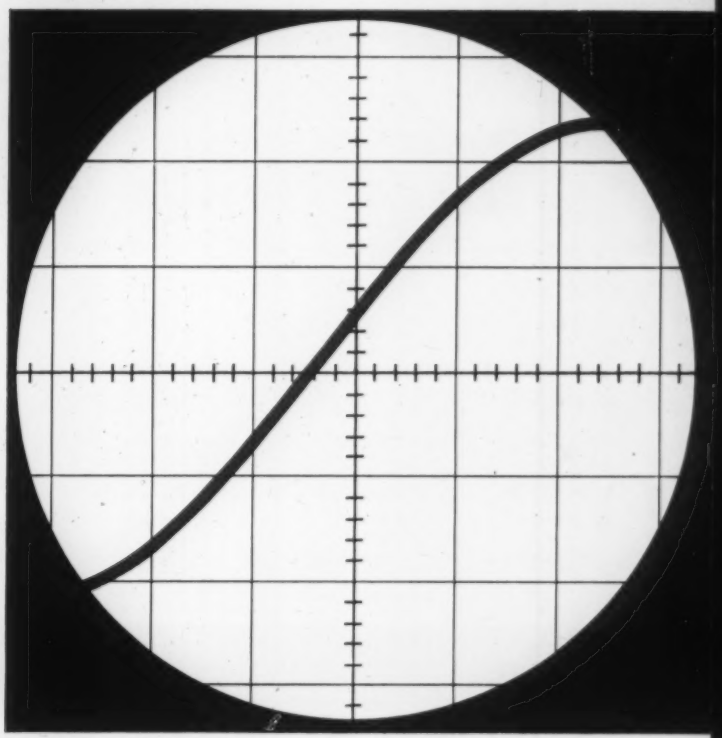
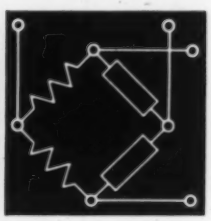
JANUARY 22, 1959

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY





# MEASUREMENT AS A DESIGN TOOL

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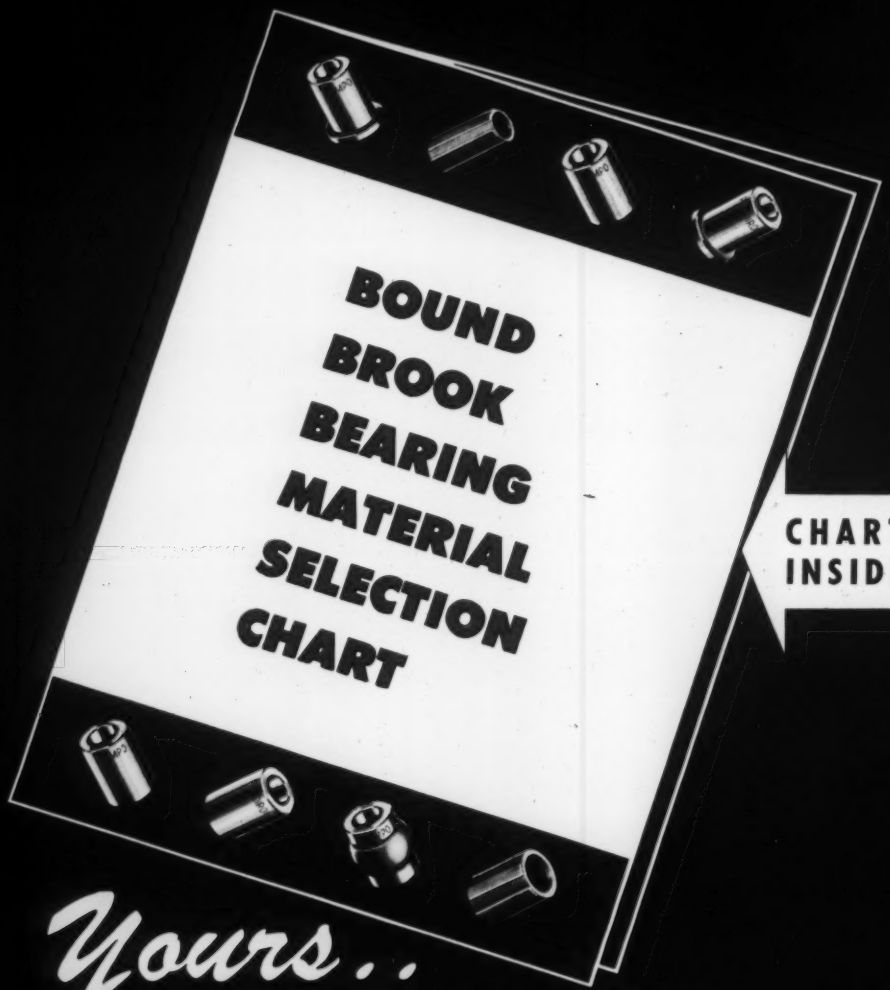


# *Yours.. for the asking*

The proper material for sintered bronze or iron bearings has always been a major problem to design men. Now for the first time a chart has been engineered, clearly showing the complete chemical, mechanical, and work characteristics of a wide range of sintered bearing materials. The best material for most applications can be selected by a draftsman in a matter of minutes. Only requests on company stationary will be honored.

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BOUND BROOK OIL-LESS BEARING CO., EST. 1883, BOUND BROOK, N. J.

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POWDER METALLURGY BEARINGS & PARTS

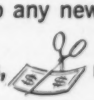
**BETTER LUBRICATION BEGINS WITH ALEMITE** **OIL-MIST**

# How to cut lubricant costs up to 90% — and increase production!

Large and small plants in many industries are making important maintenance savings while actually boosting machine output—with Alemite Oil-Mist Automatic Lubrication.

The Oil-Mist system atomizes oil into air-borne particles, carries them through tubing to all lubrication points and bathes every moving surface with a cool film of clean lubricant while machines operate. It provides constant, uniform, completely automatic lubrication to a few or to hundreds of bearings. Accurate and foolproof, Oil-Mist eliminates guesswork. No bearing can be overlooked or over-lubricated.

Three types of Oil-Mist fittings apply lubricant in the form required. Either a mist fitting or a condensing fitting or a spray fitting, is used to lubricate any lubrication point.

An Oil-Mist system can be applied to any new or installed machine. Find out in detail how it cuts costs,  reduces man-hours and machine downtime, extends bearing life, and increases production.

Write Alemite, Dept. BB-19, 1850 Diversey Parkway, Chicago 14, Illinois.

*Makers of these automatic centralized lubrication systems: Oil Mist · Accumatic · Accumite*

**1850 Diversey Parkway, Chicago 14, Illinois**

**ALEMITE** DIVISION **STEWART-WARNER CORPORATION**

Symbol of **SW** Excellence

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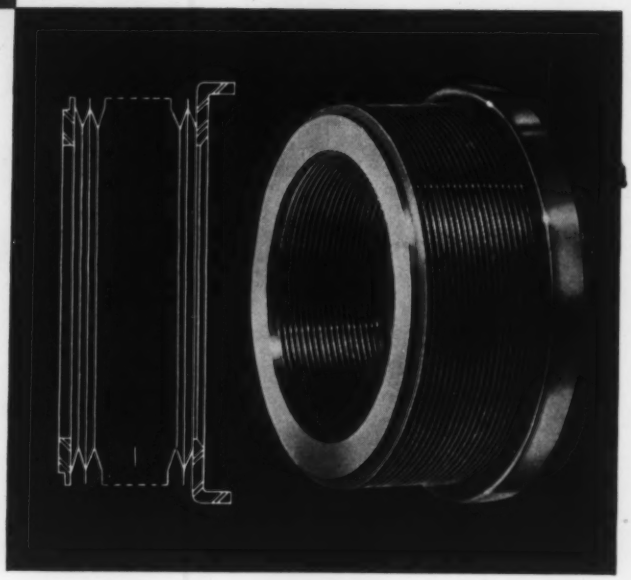
C/R DESIGN NOTES

# How C/R's New Metal Bellows Seal Meets Seemingly Impossible Operating Conditions



## Operating Ranges

| | |
|---|---|
| Temperature | −400° to 1000° F. |
| Pressure | 500 psi |
| R.P.M. | 80,000 plus |

These known operating ranges indicate the function of this seal. It is designed for applications where temperatures and mediums to be sealed forbid the use of any organic materials. Typically, these applications include fuel pumps, compressor power units and turbine starters characteristic in rockets and missiles. Other applications include mechanisms which are exposed to a high level of radioactivity.

## Design Advantages

The C/R metal bellows seal consists of a metal bellows — a welded homogeneous unit which is secured at one end — and a carrier ring in which the sealing face is mounted. The seal does not contact the shaft. It is stationary, and the only rubbing surfaces are the sealing face and mating ring. These surfaces are precision lapped to provide a positive seal with minimum friction. At any given pressure, the seal can be designed to maintain proper and constantly effective face loads. It orients immediately to run-out and will resist any torques it is subjected to in operation. The design has high end-play tolerance: Chicago Rawhide engineers have deflected a bellows .100 in. for three million cycles at 1750 cpm and at a temperature of 500° F. with no adverse effects.

A further advantage is relatively light weight and compactness. The C/R metal bellows seal can be designed for minimum axial and radial space. Axially, complete seals can be produced within a ¼ in. cross-section. Radially, dimensions are comparable with conventional end face seals.

The C/R metal bellows seal can also be designed with an extremely low coefficient of expansion. The importance of this factor becomes apparent with the fact that in many applications the operating temperature may change hundreds of degrees in a very few seconds.

## Mediums To Be Sealed

Virtually any known liquid or gas may be positively sealed with this design, depending upon duration or service life. From a practical viewpoint, the C/R metal bellows seal is the best design for the sealing of cryogenic and high-energy fuels such as LOX, hydrogen peroxide, fluorine and other missile and rocket propellants.

Where possible, lubrication of the two sealing faces is desirable to prolong service life. However, the medium being sealed commonly acts as the lubricant and may be merely hot gas.

## Materials

Sealing faces and mating rings for the C/R metal bellows seal are available in a variety of materials including carbides, ceramics and various alloyed metals for both high temperature and corrosion resistance. The bellows can be furnished in any of several metals and alloys such as stainless steel, Monel, Inconel X, Ni-Span C and other special alloy steels.

## Consult C/R Engineers

Each application for the C/R metal bellows seal is essentially a custom-design and an intimate knowledge of all conditions to be encountered must be known by Chicago Rawhide engineers to produce the correct combination of properties in the seal. Then, whether you require five, fifty or five thousand seals, Chicago Rawhide will design and produce the correct seal to solve your problem.

### *Helpful Design Data:*

*We will gladly furnish you with a design guide and space envelope data concerning the C/R Metal Bellows Seal. Just write for Bulletin MBS-1 on your company letterhead.*

**CHICAGO RAWHIDE MANUFACTURING COMPANY**

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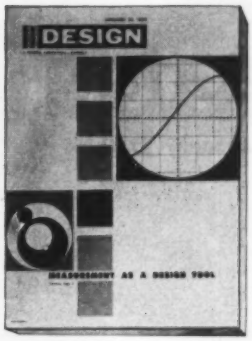


**Front Cover:** Cam and follower, strain-gage circuit, and oscillograph trace — these are the symbols used by George Farnsworth to portray modern methods of "measuring" machines and mechanisms in motion. For a closer look at this subject, see the article by Fran Fisher, beginning on Page 106.

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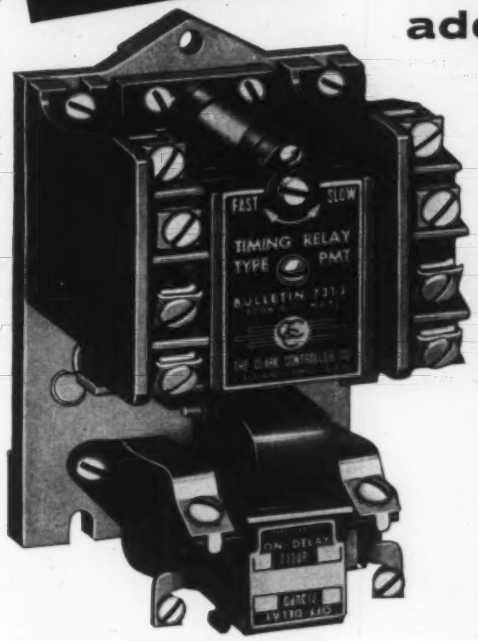
NEW!

SPACE-SAVING

# TWO CLARK RELAYS

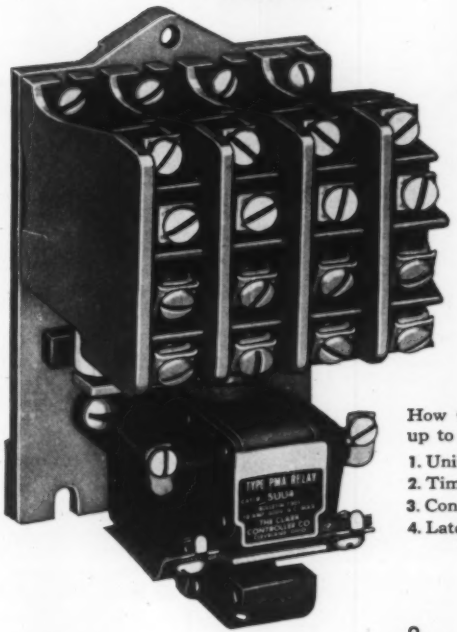
## added to the "PM" Line!...




With the addition of *Time-Delay* and *Universal Pole* Relays to its "PM" line, Clark now offers *the most complete integrated line of control relays available today!* They have the same "modular" design and match physically the Convertible Pole (Type "PM") and Latch Relay (Type "PMA").

## CLARK Type "PMT" TIME DELAY RELAYS

- Line up with other relays in the "PM" line.
- Timing head occupies space of 2 poles above magnet.
- Poles are "universal" type—each with 2 isolated contacts, one normally open, one normally closed, same as used on "PMA" relays described below.
- Available for "ON-DELAY" or "OFF-DELAY" operation (time delay after energization or de-energization). Easily convertible in the field.
- Timed and instantaneous poles are identical.
- Models available with either 2 or 4 timed contacts and up to 6 instantaneous contacts.

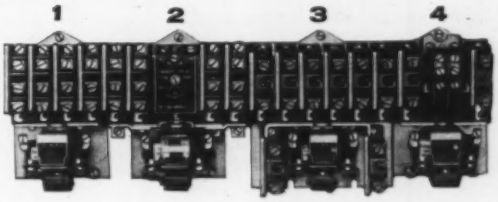


## CLARK Type "PMA" UNIVERSAL POLE RELAYS

- Line up with other relays in the "PM" line.
- Each pole contains 2 isolated contacts—one normally open, one normally closed, with 600v clearance between contacts.
- Individual poles can be removed or replaced without disturbing others. Each pole has its own arcing chamber—any short circuit is confined to one pole.
- Poles are interchangeable with convertible poles of "PM" relays.
- Models available with up to 14 contacts per relay.

How Clark Relays line up to save panel space.

1. Universal Pole Relay
2. Time Delay Relay
3. Convertible Pole Relay
4. Latch Relay

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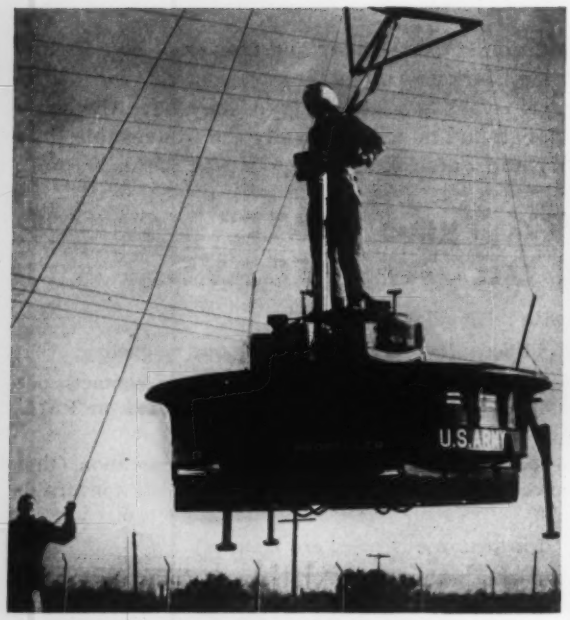

## Ducted Fans Get Safer, Bigger

**The tether is temporary** with Hiller Aircraft's latest Flying Platform, shown here during initial test flights (left). Growing out of earlier single-engine designs, the new ducted-propeller vehicle couples three engines to the fan for increased reliability. Big brother of the one-man platform is the VTOL weight lifter (right), now under preliminary design study for the Navy. Ducts rotate from the vertical to provide forward-flight thrust. Considerably more efficient than the conventional helicopter, the wingless weight lifter is intended for relatively slow-speed, flying-crane duty.

## 1958 Metals Developments Indicate Bigger Things in '59

### ASM President Reviews Major Metals Achievements

CLEVELAND—Adaptation of 30,000-F plasma-jets to surface coating . . . new explosive-forming techniques for metal shaping . . . two steels, one with tensile strength of more than 400,000 psi . . . and rolling metal strip directly from powder . . . these developments head a list of recent achievements cited as forerunners to advancements in 1959.

Dr. Clarence H. Lorig, president of the American Society for Metals and technical director of Battelle Memorial Institute, observes that "we are on the threshold of even greater achievements in meeting space-age demands." In a year-end report, Dr. Lorig highlighted last year's "huge strides by our metals experts," who today are working with metals for temperatures as low as −434 F and as high as 5000 F."

#### *The 'cold' facts . . .*

The low-temperature extreme is, of course, a problem associated with liquid fuels for missiles. Only a few metals retain ductility at temperatures near absolute zero, and then only under certain conditions. Some stainless steels and certain copper, aluminum and titanium alloys can be used for storing liquefied gases, but many problems associated with their fabrication remain unsolved.

#### *. . . and a new hot process*

The plasma-jet, originally intended to simulate heat conditions encountered at hypersonic speeds, is now being adapted to metal production. Temperatures up to 30,000 F make possible melting and application of metals and compounds with extremely high melting points. Besides producing parts that withstand high temperatures, the process is expected to be used in making electronic parts and special chemical process assemblies from materials that might not otherwise be formable.

#### *Steels get more muscle*

Two new steels introduced last year offer high strength, excellent formability, and weldability. One is an air-cooling, ultrahigh-strength alloy with tensile strengths up to 280,000 psi; the other—still virtually in the laboratory stage—has shown strengths to 400,000 psi, the

An announcement of interest to manufacturers of steel parts

# Improvements in today's STRESSPROOF STEEL BARS WITH COPPER

**1** **100,000 PSI YIELD STRENGTH** in all sizes . . . without heat treating.

**2** **IMPROVED PHYSICAL PROPERTIES...** better fatigue life wearability, and resistance to atmospheric corrosion. Over-all quality is improved.

**3** **IMPROVED MACHINABILITY...** STRESSPROOF with copper now machines faster and better than ever. It gives longer tool life, better finish, and more production from a day's run, according to shop production records.

**4** **CLOSER TOLERANCES...** Tolerances for rounds have been tightened to meet the need for more precise parts as follows:

| ¼" to 1½" | Over 1½" to 2½" | Over 2½" to 3⅜" |
|---|---|---|
| +.000<br>−.004 | +.000<br>−.005 | +.000<br>−.006 |

**5** **COMPARED WITH OTHER STEELS, STRESSPROOF COSTS EVEN LESS TODAY...** Also saves machining and heat treat costs, and you get a better quality part. It will pay you to take another look at this improved material.

Your STEEL SERVICE CENTER stocks contain today's STRESSPROOF. It has been produced and shipped over a several months' period.

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JUST PUBLISHED! Use this coupon to request your copy of new bulletin, "Improvements in Today's STRESSPROOF Steel Bars."

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Circle 407 on Page 19

highest reached by any metal. It is also reported to have high ductility at temperatures as low as −385 F.

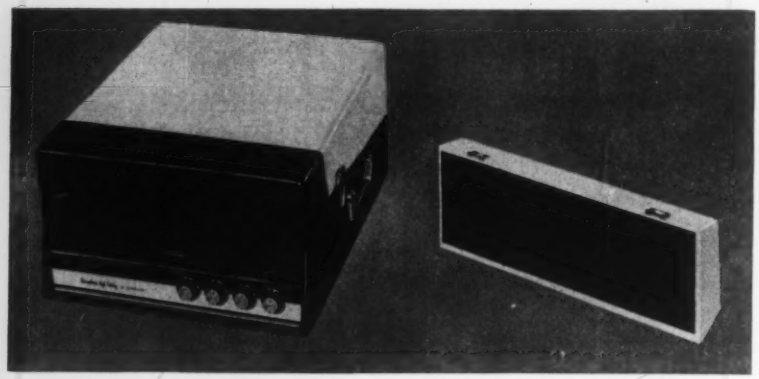
### Big boom in forming

Explosive forming, which takes advantage of the creation of a viscous state in metals through application of high pressure, produces complicated shapes — sometimes without dies. Usually dynamite or TNT provides the energy, but a machine has been developed which exerts extremely high pressures pneumatically and releases them with virtually no time delay. In addition to producing shapes which might ordinarily be made only in huge presses, explosive force is also being considered for such tasks as surface hardening of steel, riveting, hole piercing, embossing, compacting of metal powders, forging, bonding, and casting under pressure.

### Progress in powders

Advancement in metal powders is in two areas: Production of parts from a new low-alloy iron powder with strengths up to 190,000 psi and rolling of metal strip directly from metal powders. Copper and nickel have been rolled to thicknesses of 0.050 to 0.060 in. in widths up to 11 in. at a rate of 6 fpm.

Other projects claiming the attention of metals experts are electron-beam vacuum melting, a process which produces extremely pure metals by melting in a vacuum chamber with an electron gun; development of three new titanium alloys, one of which can be heat treated to 240,000-psi strengths; and coated, corrosion-resistant steels.



## Portable Stereo Carries Second Speaker in Cover

**Stowaway auxiliary** speaker snaps out of the lid of a portable stereo phonograph. Placed up to fifteen feet apart, the two speakers give true stereophonic reproduction through dual-channel amplifiers. Developed by Admiral Corp., the unit will be available in three luggage-type models this year.

## Atomic Energy Powers RR Light

**Beta particles from Krypton 85** are the only source of energy for New York Central's new atom-powered switch light. Visible light results when beta rays strike a phosphorescent coating inside the bulbs holding the krypton gas. Development problem was balancing nuclear-power output with proper shielding to give a bright, yet safe light. Present version, which uses bulbs supplied by U. S. Radium Co., Morristown, N. J., has been fully approved by the AEC. Lantern body and shielding were developed by New York Central's Research Lab in Cleveland.

# Topics

**Jack Frost is foiled** by a defrostable rear-view mirror for cars and trucks. De-icing—accomplished in three minutes at zero temperatures—is done electrically, the vehicle's battery furnishing current to a conductive coating on the back of the mirror. Spartan Automotive Co., Jackson, Mich., markets the hot mirrors.

• • •

**Gamma rays and goobers** have combined to produce what scientists call a "milestone in fundamental genetics." An improved strain of peanuts resulted from atomic radiation of peanut seeds. The new peanut has thicker shells, fewer damaged kernels and growth cracks, and is more resistant to disease. Neither plant nor seeds are radioactive, and the peanuts are edible.

• • •

**Pushbutton blues threaten workers** in automated factories, according to a French psychiatrist who has studied "human problems" of automation. A seven months' investigation of conditions at a Renault plant which is the most fully automated car factory in the world indicates that mental disturbance stemming from a sense of isolation and loneliness is an occupational hazard of button-pushing. A conclusion of the study is that workers must be made to feel that they are part of a team effort. As a start, it was suggested that machines be placed in groups of two or three.

• • •

**Research is only skin deep** in a Navy project aimed at measuring effects of radiation such as a pilot may face from direct sunlight high above the earth. In a device used in experiments, material simulating human skin is laid over a metal cylinder. Temperature is controlled above and below the material, and instruments measure the temperature through it. Results of the research will serve as a guide for specifying protective clothing and proper atmospheres for high-flying pilots.

• • •

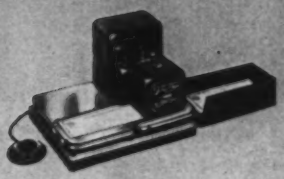
**Diamonds are a road's best friend** when they are used in a machine that trims surface irregularities from pavement. The "bump cutter," which was originally developed to smooth jet runways, has been used to finish a new section of the Illinois Tollway. This machine, employing a principle similar to a reel-type lawnmower, uses approximately 2000 carats of diamond in 100 parallel rows, to trim small surface bumps. Smoother highways not only provide increased driver safety and comfort, but lower upkeep costs by reducing impact of heavy loads against even small bumps.

# HERE'S WHY..

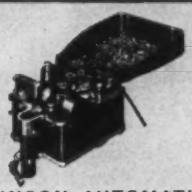
## *Leading business machine manufacturers power their products with Bodine Motors*

ROYAL ELECTRIC TYPEWRITERS. "Bodine Motors were selected because of their convenient, compact size; quietness; and efficient operation which turns out a true rated power. Reliability, of course, was our first consideration." — Royal Typewriter Division, Royal McBee Corporation.

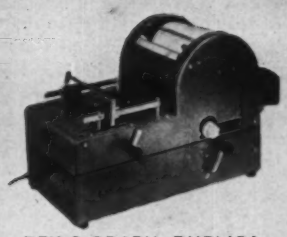
REMINGTON RAND AUTOMATIC CALCULATORS. "We require a motor with a high torque for its size. Bodine Motors meet these requirements without excessive temperature rise . . and they're exceptional for reliability and performance." —B. H. Tingley, development engineer.



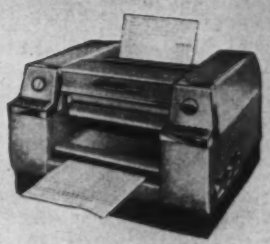
HEDMAN CHECK WRITERS. "We require motors that are small, quiet, sturdy, long lasting, trouble free, and supply the high torque needed. We've used Bodine Motors for 36 years . . their engineers are always willing to help with our motor problems." —C. W. Johnson, vice president.



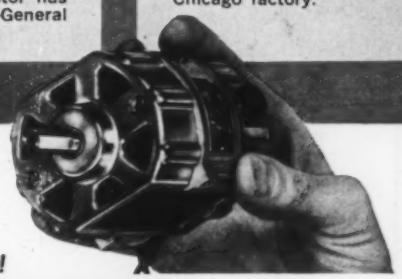
JOHNSON AUTOMATIC COIN COUNTERS. "We required a small, powerful motor for our coin counters . . and were able to obtain a motor that fitted our needs from Bodine's wide selection. We have used Bodine Motors for over 13 years, and find them to be extremely reliable." —Johnson Fare Box Company.



REX-O-GRAPH DUPLICATORS. "We tested all induction type motors. Bodine was the only one that met our requirements in starting torque, weight, breakdown torque, size, and reduction gear dimensions. Service on this motor has been almost nil."—General Binding Corp.



BRUNING COPYING MACHINES. "The only reason we buy Bodine Motors is that we could not buy a product of equal quality elsewhere." —John P. Arndt, works manager, Chicago factory.



***New model business machine motor!***

Ask for a copy of newly published Technical Bulletin #1034. It tells the story of Bodine's newest model business machine motor . . the FSE-23. It's only 2 5/16" high . . weighs only 1 pound, 11 ounces . . packs plenty of power. And it's rectangular in shape . . fits into minimum space. Send your request to Bodine Electric Company, 2508 W. Bradley Place, Chicago 18, Illinois.

**BODINE**
fractional horsepower
**MOTORS**

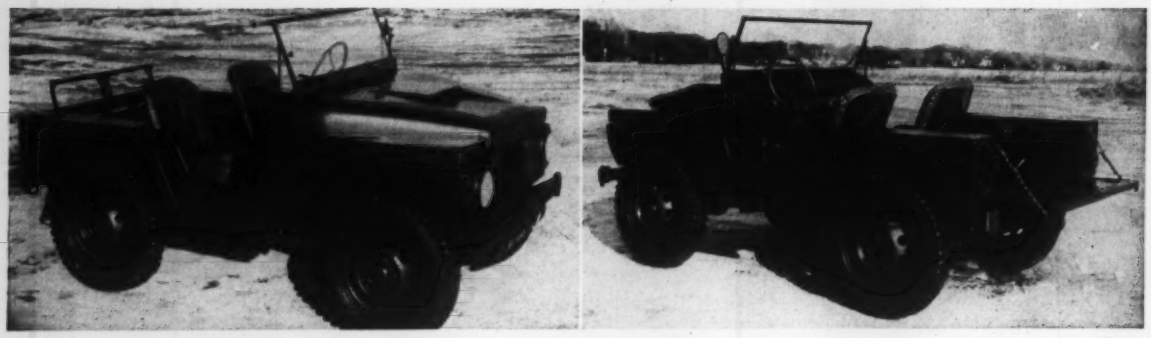
BODINE

*Other applications for Bodine Motors:* vending machines, instruments, communication equipment, sound recorders, automatic scales, respirators, voltage regulators, X-ray timers, traffic signal timers, stirrers, sanders, letter openers, envelope sealers . . plus many, many other applications.

***...the power behind the leading products***



Circle 408 on Page 19



## Marine's Mighty Mite Makes Ready

**Set for rugged tests on the proving ground,** first production pilot models of American Motors' Mighty Mite roll out after five years of intensive powerplant and chassis development. Grossing only 1700 lb, the new Marine Corps vehicle climbs 100 per cent grades, fords 60-in. deep streams. Mite's 55-hp engine is an aluminum, air-cooled V-4 and weighs 303 lb; displacement is 108 cu in., and compression ratio is 7.5:1. Designed to be airborne by helicopter, Mite has a top speed of 62 mph and can chug along at a minimum speed of 2.5 mph. After evaluation and tests by AM and the Corps, the vehicle will go into production at AM's Special Products plant in Detroit.

## Big Flywheels Store Energy For Hypersonic Wind Tunnel

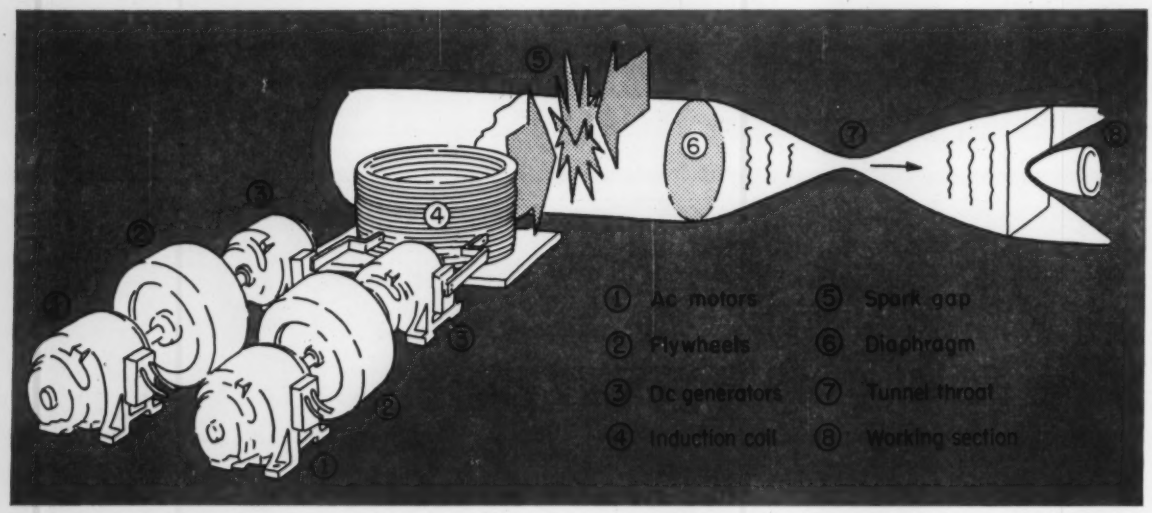
### Mechanical "Battery" Cuts Cost To 42 Cents per Shot

SCHENECTADY, N. Y.—Massive spinning flywheels form the unique "charged source" of energy for a hypersonic shock tube being built at AF's Arnold Engineering Development Center, Tullahoma, Tenn. Brought up to speed by squirrel-cage motors, the flywheels are clutched to direct-current generators for mechanical-to-electrical energy conversion. Electrical energy — stored briefly in an outsized induction coil — produces a 120-million joule spark to fire the tunnel.

Called "Hot Shot," the tunnel develops Mach-20 airflows in a test section big enough to accommodate full-scale nose cones, missiles, and rocket components. Like all shock-tube test facilities, Hot Shot maintains design air speed for only a fraction of a second. However, such short bursts of hypersonic air are enough for most test purposes. The new AEDC facility, incorporating a 7 by 7-ft working section, requires approximately ten times the energy of present small-scale shock tubes.

The tunnel works by heating compressed air in a small vessel by a high-intensity arc. The air, at great heat and pressure, bursts a frangible diaphragm and expands smoothly through a nozzle.

Bringing the twin flywheels to 1800-rpm "firing" speed is a slow process because of their tremendous inertia. Measuring 76 in. diam. by 64 in. thick, each flywheel weighs 47 tons. From a cold start, the 1000-hp drive motors can accelerate the flywheels in 15 min. During subsequent firings, the heated motors require 30 min to fully charge the




**Forty-seven ton flywheels,** driven by 1000-hp ac motors, store 650 million watt-seconds of energy in the Hot Shot tunnel. Converted to electrical energy in dc generators, power is stored in an 11-ft diam induction coil until used to fire the 1,000,000-amp, 20,000-v spark. Test section of the Mach-20 wind tunnel measures 7 by 7 ft—large enough to accommodate full-scale models. This sketch is artist's conception of hot shot component arrangement.

# ARISTOLOY

## Electric Furnace Steels

BEARING QUALITY • AIRCRAFT • PISTON PIN QUALITY • ELECTRIC FURNACE ALLOY • ELECTRIC FURNACE CARBON • ALLOY BASE ALLOY • QUALITY CARBON

LEADED—Electric Furnace 52100 • Electric Furnace Alloy • Electric Furnace Carbon • Alloy Base Alloy • Quality Carbon

STAINLESS—300 Series • 400 Series • 500 Series

FURNISHED AS—Hot Rolled Blooms, Billets & Bars • Hot Rolled, Annealed & Heat Treated • Ground Blooms & Billets • Bars—Hot Rolled, Turned, Turned, Ground & Polished, or Cold Drawn with or without Heat Treatment

NEW PRODUCTS & FACILITIES CATALOG

ARISTOLOY STEELS

COPPERWELD STEEL COMPANY

ARISTOLOY STEEL DIVISION • 4017 Mahoning Ave., Warren, Ohio • EXPORT: Copperweld Steel International Co., 225 Broadway, New York 7, N. Y.

flywheel "batteries." At full speed, flywheels store 650 million watts of energy.

The system will be able to repeat the firing cycle every half hour. Total energy delivered in each pulse is not great—about 42 cents' worth of electricity (at average retail rates). Only 2500 kva will be drawn from AEDC's electrical system.

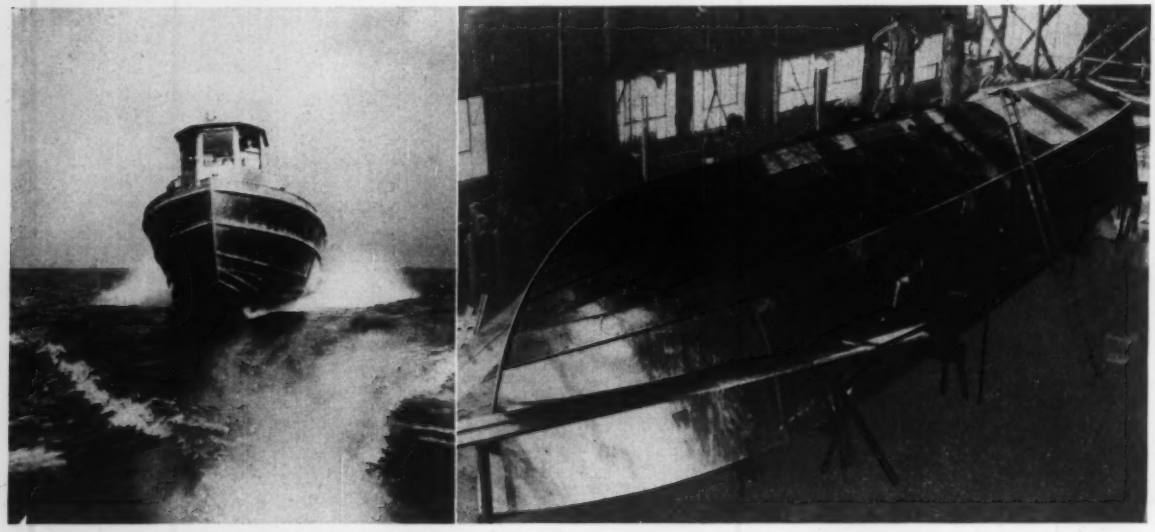
The air-core induction coil, believed to be the largest ever built (11 ft diam:, 5 ft high, and weighing about 60 tons) will be braced to withstand a clamping force of 12 million lb at its midpoint. The enormous magnetic field, created by the current passing through the coil, tends to squeeze it like a spring.

Switches and protection systems are being specially designed to handle the unusually high currents developed in Hot Shot. A remotely operated pneumatic-powered disconnect will probably qualify as the world's largest switch. Capable of carrying 1,000,000 amp for one-fourth of a second, it will serve as an isolating device.

All electrical equipment for Hot Shot is being designed and built by General Electric.

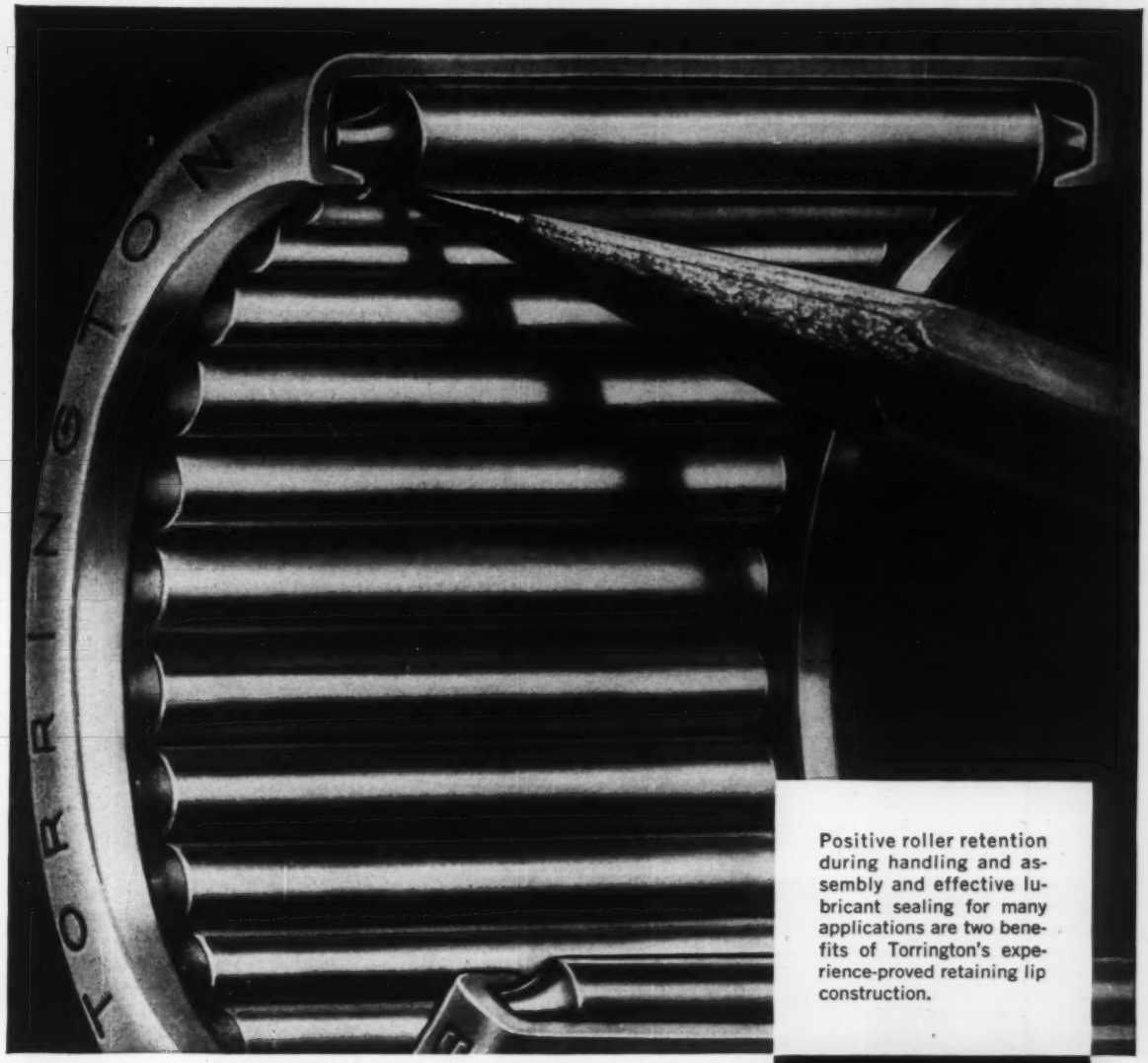
## New Look in No-Kink Tube Benders

**Top-quality bends in the half mile of thin-wall tubing** in Boeing's B 52 are made on a new flexible-ball mandrel. More versatile and durable than its predecessors, the Free-Flex mandrel handles stainless-steel or aluminum tubing in diameters ranging from 1 to 6 in. Flattening or crushing of tubes during bending are eliminated by a series of steel supporting balls, interconnected by spherical-ended pins. Bends can be made on radii down to twice the tube diameter. Developer of the mandrel—Boeing Airplane Co.—has granted manufacturing rights to Pines Engineering Co. Inc., Aurora, Ill.

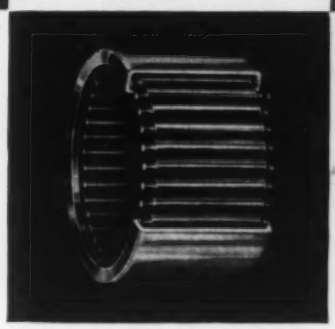


## Polyhedral Hull Gives Fast, Smooth Ride

**Stability at speeds up to 40 mph is achieved in this all-aluminum boat with a saw-tooth hull.** Faired out to a smooth bottom in about half the length of the boat, the steps cushion the drop of the bow and give a fast, stable ride in 3½-ft waves. To push the boat to 40-mph speeds, two gas turbine engines built by Solar Aircraft Co. develop 500 hp apiece. Approximately 10 tons of 5456 aluminum sheet and plate, ranging from 3/16 to 1 in. in thickness, were used for hull plates and frames. The boat was designed for personnel transport, patrol, and rescue work where speed and stability in rough water are vitally important characteristics.




Positive roller retention during handling and assembly and effective lubricant sealing for many applications are two benefits of Torrington's experience-proved retaining lip construction.



# This little lip makes a big difference!

The turned-in lip at each end of Torrington Needle Bearings positively retains the trunnion - end rollers and makes the bearing truly a complete unit, with no possibility of roller fall-out.

This unit construction simplifies installation and servicing. The closely controlled clearance and the large area between cup lips and shaft form an effective labyrinth seal. Also this retaining lip allows pregreasing the bearing with the proper lubricant for each application.

Long experience with the Torrington Needle Bearing in thousands of applications has proved the merit of this and other features in efficient performance and long service life. Make sure *your* product benefits from the best that experience has to offer—specify Torrington Needle Bearings. **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

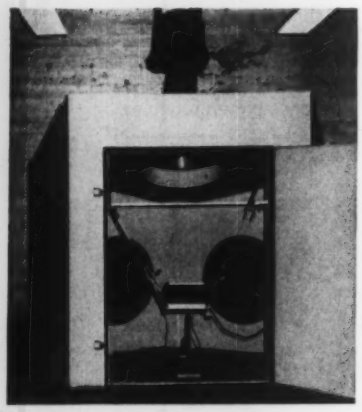
## TORRINGTON BEARINGS

*District Offices and Distributors in Principal Cities of United States and Canada*

**NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE ROLLERS • BALL • THRUST**

## Minimum Helicopter Licks Stick Shake

**Extreme stability and freedom from vibration allow this tiny copter to be flown hands-off.** Hedgehopping abilities and small silhouette make it an elusive target for enemy fire. Although the YHO-2HU was designed for Army reconnaissance, liaison, and training, the developer—Hughes Tool Co., Aircraft Div., Culver City, Calif.—kept an eye on civilian requirements. Completion of CAA approval programs will establish a commercial version, model 269A, for what is predicted to be a large civilian market. Simplicity, economy, and stability are outstanding design features of the craft. Vital parts are easily accessible for maintenance; the Lycoming 0-360 engine unit can be changed in 45 min by three men without hoists or unusual tools. Useful load is 635 lb; range is estimated at 180 miles at 65 mph; service ceiling is 11,000 ft. Autorotative descent rate is 1400 fpm.



## Noisiest Spot at G.E.

**Three 600-w loudspeakers** aimed into a small box provide shattering noise for testing electronic and mechanical components used in Atlas and Thor missiles. Parts being tested are suspended on elastic cords inside the 120-cu ft chamber and blasted with a 145-db roar. Complete nose cones are tested by allowing the noise to flow into a larger room. Built by General Electric, the acoustic chamber has seven irregular interior walls to avoid parallel alignment.

## Six Countries Agree on New Yard and Pound

WASHINGTON—The National Bureau of Standards has announced, in co-operation with corresponding bodies from five other nations, a new international standard for the yard and pound based on metric standards. It may not have bothered too many people, but the old U. S. pound is nearly 0.00000009 kg heavier than the British pound. The Canadian pound is even heavier.

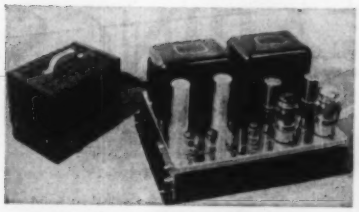
Since modern scientific methods cannot tolerate such discrepancies, a compromise international pound was chosen weighing 0.45359237 kg. This figure is exactly divisible by seven, so it makes a grain exactly 0.06479891 gm. For similar reasons, an international yard was chosen that is 0.9144 long. This makes an inch exactly 25.4 mm.

Until now, linear values used by NBS were those proposed by Mendenhall for the U. S. Coast and Geodetic Survey. These are based on the exact relationship: 1 yd = 3600/3937 international meter. For the time being, Geodetic Survey records and data will continue to be expressed in these units.

Nations co-operating in establishing the new units are Canada, Great Britain, South Africa, New Zealand, Australia, and the United States. The announcement is being made concurrently in all of these countries.

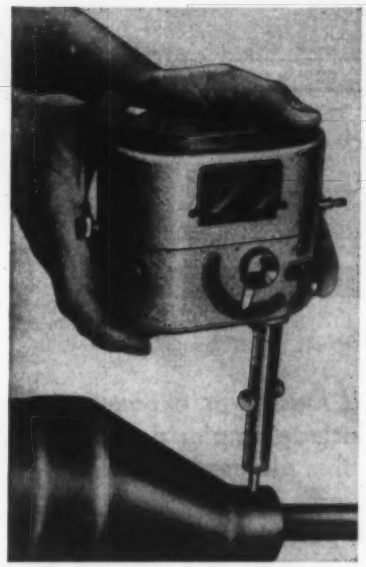
## Vanguard Lube Is Safe In Liquid-Oxygen Lines

CHESTERTOWN, MD. — Couplings, valves, and other moving parts in liquid-oxygen lines are safely lubricated with a synthetic compound in the Vanguard rocket. Explosion dangers of conventional hydrocarbon lubricants in the presence of pure oxygen are eliminated. The new compound, called LOX lubricant X-1333, is a development of Lehigh Chemical Co., Chestertown, Md. Martin Co., builder of Vanguard, has written a specification (MCI 20202) on this lubricant.



### *Loud Midget Bawls Train Times*

**Power to page passengers** and announce trains in large depots is handled by this miniature transistorized amplifier. Rated at 75 w, the midget amplifier (left) is the equivalent of the conventional vacuum-tube unit (right). Finding none on the market, New York Central's Research Laboratory put together this prototype. NYC also has a 20-w amplifier designed for use in a portable electronic megaphone.



### *Mechanical Linkage Marks Tape*

**Hand-held mechanical vibration recorder** uses the impulses of the vibration source to mark a 1-in. ink or waxed tape. Tape speed can be adjusted from 70 to 275 in. per min to make a readable graph of frequencies from 0 to 20,000 cpm. Amplitudes from 0.0004 to 0.8 in. can be magnified 2, 4, 5, 10, or 20 times. Tape is stored on a take-up reel in the body of the instrument. In a typical application, the Hand Vibrograph, made by Korfund Co. Inc., Long Island City, N. Y., checks vibration level of machinery. Periodic checks thereafter can be compared with the original graph to assess wear of moving parts. It also records rotational speed of equipment when shaft is not accessible.


# 900° F. STOCK BEARINGS

## PERMIT RAPID SOLUTIONS TO HIGH-TEMP PROBLEMS

| | |
|---|---|
| TYPE: Deep groove radial. | RETAINERS: Machined, land riding. |
| SIZES: 200, 202, 204 and 206. | ACCURACY: ABEC-5. |
| BALLS AND RACES: High speed steel. | LUBRICATION: None. |

THESE NEW ITI ball bearings are for use at elevated temperatures up to 900° F. At such temperatures, their load capacity is greater than any other bearings of like size, and they have unusual dimensional stability. They open new horizons in developmental work, because (1) they provide a first approximation to the solution of a wide range of high-temperature bearing problems; (2) they're *available from stock;* and (3) they *cost far less* than custom-made experimental bearings.

The suitability of a bearing to *any* high-temperature application depends on many factors.* Upon receipt of application data, we will tell you whether these "off-the-shelf" bearings will serve your purpose. Prices and other details are also available; and we invite your inquiry.

*FREE BULLETIN AFB-2 gives details; also describes our work in *custom-engineered* bearings. Write for it.

**INDUSTRIAL TECTONICS, Inc.**

ITI

MANUFACTURERS OF PRECISION BALLS AND BEARINGS

3682 JACKSON RD., ANN ARBOR, MICH.

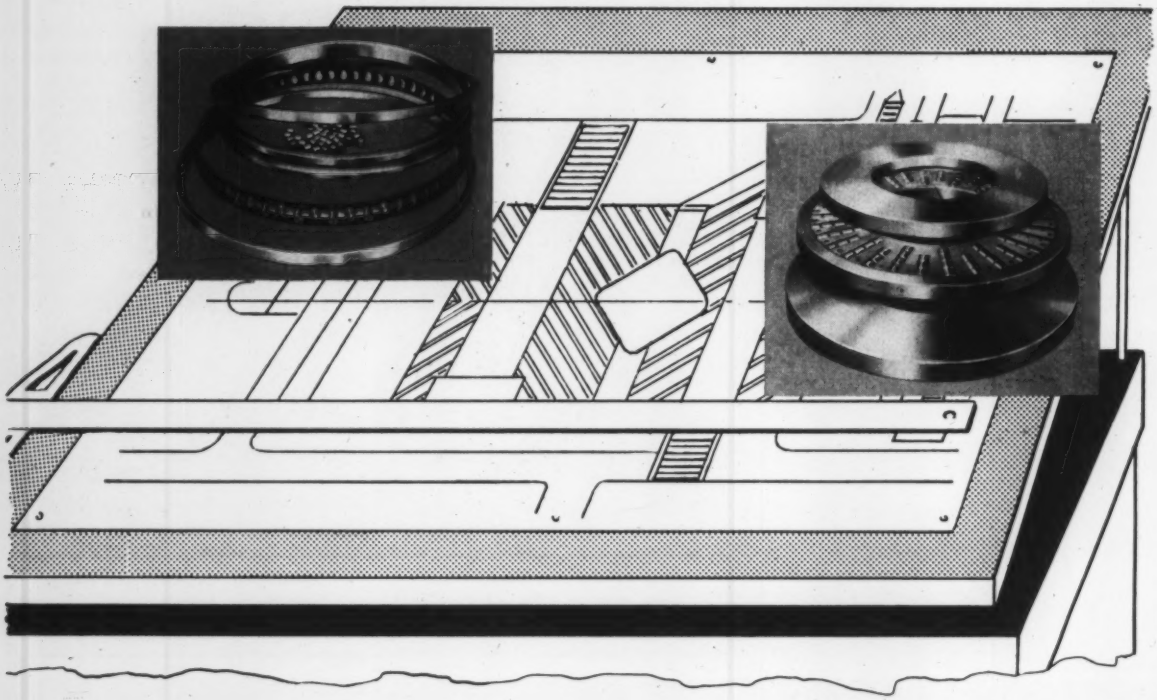
WESTERN DIVISION PLANT: COMPTON, CALIFORNIA





Circle 411 on Page 19

# *Put* MESSINGER BEARINGS *on the Drawing Board*



When design calls for bearings, it will pay to have a Messinger engineer "sit in" at the earliest stage. The result is very likely to include simpler design, lower manufacturing costs and greater efficiency of the planned product or equipment.

Backed by nearly half a century of engineering experience, Messinger Bearings provide heavy capacities in smaller space and with less weight; assurance of long, trouble-free service life; and adaptability to the widest range of size and shape requirements.

*Consultation Invited without Obligation*

*Smoothing Industry's Pathway* MB *...for Nearly Half a Century*

# MESSINGER BEARINGS, INC.

**D STREET ABOVE ERIE AVENUE, PHILADELPHIA 24, PENNA.**

**BALL AND ROLLER BEARINGS • FEATHERWEIGHT TO HEAVYWEIGHT**

# Reader Information Service

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## USE A YELLOW CARD
## *for More Information . . .*

**CIRCLE ITEM NUMBERS**—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

**EDITORIAL CLIPSHEETS**—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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| | | | | | | | | | | | | | | |
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| 401 | 426 | 451 | 476 | 501 | 526 | 551 | 576 | 601 | 626 | 651 | 676 | 701 | 726 | 751 |
| 402 | 427 | 452 | 477 | 502 | 527 | 552 | 577 | 602 | 627 | 652 | 677 | 702 | 727 | 752 |
| 403 | 428 | 453 | 478 | 503 | 528 | 553 | 578 | 603 | 628 | 653 | 678 | 703 | 728 | 753 |
| 404 | 429 | 454 | 479 | 504 | 529 | 554 | 579 | 604 | 629 | 654 | 679 | 704 | 729 | 754 |
| 405 | 430 | 455 | 480 | 505 | 530 | 555 | 580 | 605 | 630 | 655 | 680 | 705 | 730 | 755 |
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| 409 | 434 | 459 | 484 | 509 | 534 | 559 | 584 | 609 | 634 | 659 | 684 | 709 | 734 | 759 |
| 410 | 435 | 460 | 485 | 510 | 535 | 560 | 585 | 610 | 635 | 660 | 685 | 710 | 735 | 760 |
| 411 | 436 | 461 | 486 | 511 | 536 | 561 | 586 | 611 | 636 | 661 | 686 | 711 | 736 | 761 |
| 412 | 437 | 462 | 487 | 512 | 537 | 562 | 587 | 612 | 637 | 662 | 687 | 712 | 737 | 762 |
| 413 | 438 | 463 | 488 | 513 | 538 | 563 | 588 | 613 | 638 | 663 | 688 | 713 | 738 | 763 |
| 414 | 439 | 464 | 489 | 514 | 539 | 564 | 589 | 614 | 639 | 664 | 689 | 714 | 739 | 764 |
| 415 | 440 | 465 | 490 | 515 | 540 | 565 | 590 | 615 | 640 | 665 | 690 | 715 | 740 | 765 |
| 416 | 441 | 466 | 491 | 516 | 541 | 566 | 591 | 616 | 641 | 666 | 691 | 716 | 741 | 766 |
| 417 | 442 | 467 | 492 | 517 | 542 | 567 | 592 | 617 | 642 | 667 | 692 | 717 | 742 | 767 |
| 418 | 443 | 468 | 493 | 518 | 543 | 568 | 593 | 618 | 643 | 668 | 693 | 718 | 743 | 768 |
| 419 | 444 | 469 | 494 | 519 | 544 | 569 | 594 | 619 | 644 | 669 | 694 | 719 | 744 | 769 |
| 420 | 445 | 470 | 495 | 520 | 545 | 570 | 595 | 620 | 645 | 670 | 695 | 720 | 745 | 770 |
| 421 | 446 | 471 | 496 | 521 | 546 | 571 | 596 | 621 | 646 | 671 | 696 | 721 | 746 | 771 |
| 422 | 447 | 472 | 497 | 522 | 547 | 572 | 597 | 622 | 647 | 672 | 697 | 722 | 747 | 772 |
| 423 | 448 | 473 | 498 | 523 | 548 | 573 | 598 | 623 | 648 | 673 | 698 | 723 | 748 | 773 |
| 424 | 449 | 474 | 499 | 524 | 549 | 574 | 599 | 624 | 649 | 674 | 699 | 724 | 749 | 774 |
| 425 | 450 | 475 | 500 | 525 | 550 | 575 | 600 | 625 | 650 | 675 | 700 | 725 | 750 | 775 |

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No Postage Stamp Necessary If Mailed in the United States

POSTAGE WILL BE PAID BY—

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**Penton Building**
**Cleveland 13, Ohio**

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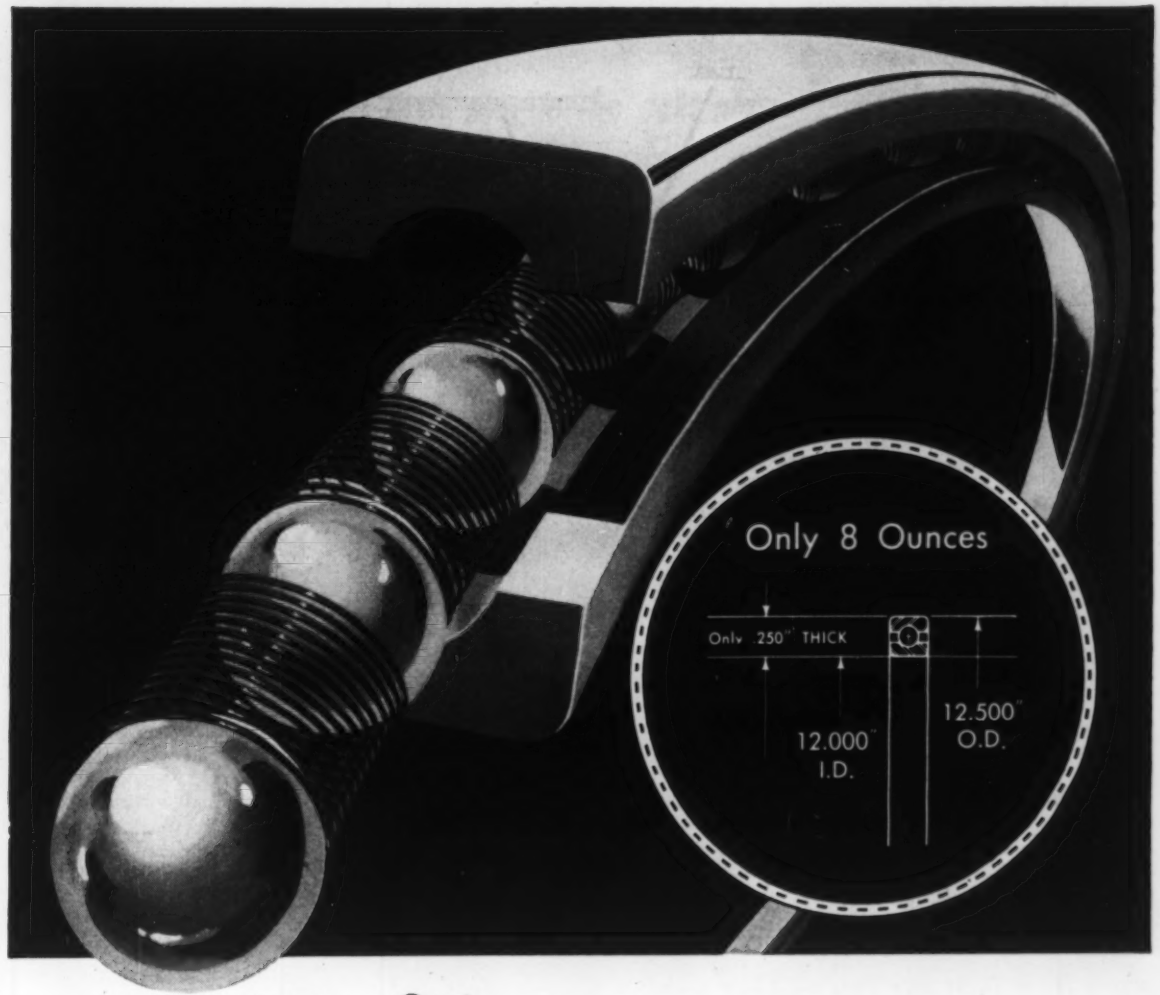



# *Reali-Slim* ... by Kaydon
## world's thinnest radial ball bearing

HERE'S a typical example of Kaydon's *Reali-Slim* unique radial ball bearing that's finding wide application in practically every industry. *Reali-Slim* are the world's finest thin-section bearings and proportionately are thinner than a wedding ring. The bearing illustrated here is 12.000" I.D., 12.500" O.D., .250" thick — weighs less than 8 ounces. Designed for minimum weight and space limitations, it has a static load capacity of 5,520 lbs. and 894 lbs. at 100 rpm.

If you're looking for *Reali-Slim*, lightweight, radial ball or roller bearings, look at Kaydon's *Reali-Slim* line. Besides hundreds of standard *Reali-Slim* designs, there's a wide variety of special races, seals and separators to meet special bearing problems. What's more Kaydon is able to produce these *Reali-Slim*, high-precision bearings because Kaydon specializes in the unusual. In addition, Kaydon bearing engineers are prepared to give you valuable help with technical bearing application problems.

For complete data on *Reali-Slim* bearings for standard or special applications, ask for engineering Catalog No. 54 RS.

***Reali-Slim* Ball Bearings** — in Conrad, angular contact, 4-point contact and other types are available in seven standard cross sections from .250" to 1" and in bore diameters from 4" to 40".

***Reali-Slim* Roller Bearings** — in radial or taper roller types are available in cross sections from 5/16" and in bore diameters from 5" to 40".

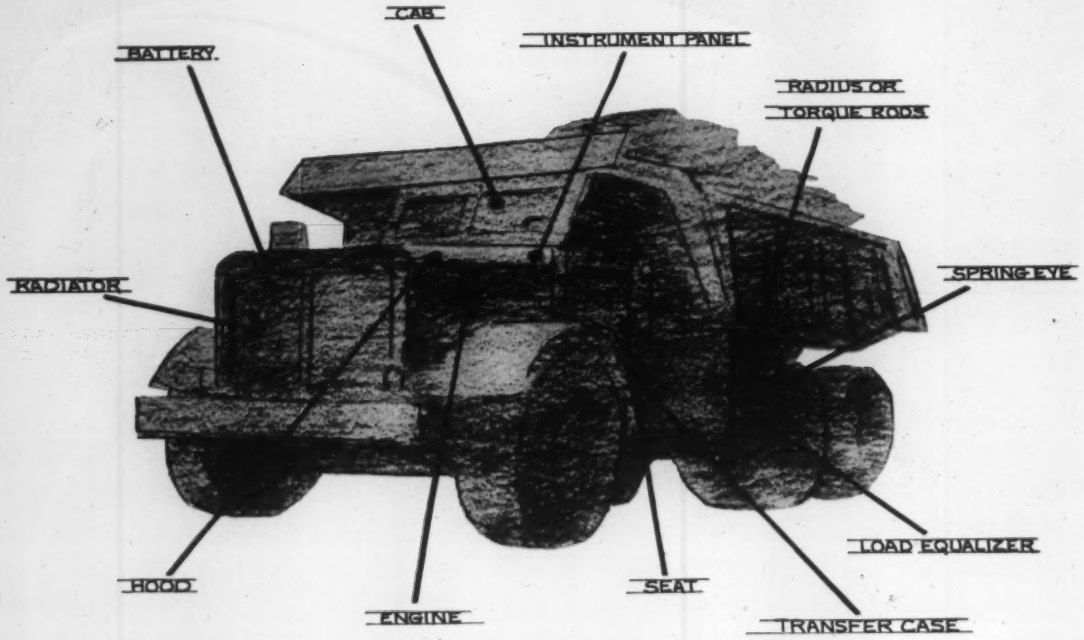
K-554

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

*All types of ball and roller bearings — 4" bore to 178" outside diameter ...*
*Taper Roller • Roller Thrust • Roller Radial • Ball Radial • Ball Thrust Bearings*


Circle 413 on Page 19




*Until now, slow operating speeds expected from off-highway vehicles have saved both men and machines from being shaken apart. Today, with the U. S. roadbuilding program gaining momentum, construction engineers are demanding a bigger day's work from their equipment. They want scraper-loaders and off-highway trucks that will carry big payloads at 50 mph. Cushion mountings and flexible joints—low-cost protection against road shock and vibration—offer one method of . . .*

# taming the rough riders

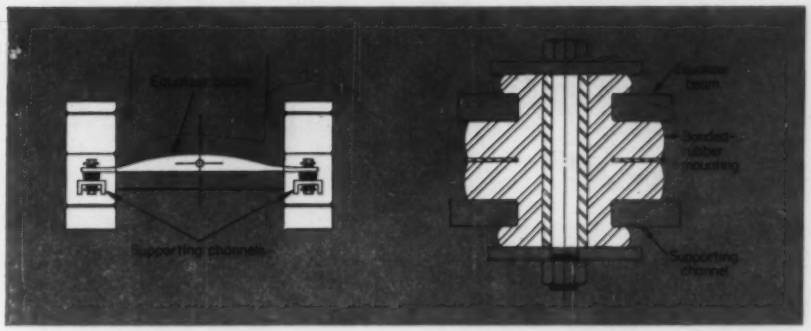
**By M. G. BECK**
Product Engineer
Lord Manufacturing Co.
Erie, Pa.

AUTOMOBILE DESIGNERS are old pros at smoothing out rough roads. Soft suspension systems, plus flexible mountings for almost everything but the spare tire, practically eliminate road shock and vibration in the family car. Some of these ideas are beginning to show up on new, high-speed off-highway equipment. Resilient mountings for engines, radiators, scraper blades, and other components offer a simple, yet effective means for keeping the rough-riding vehicles in one piece.

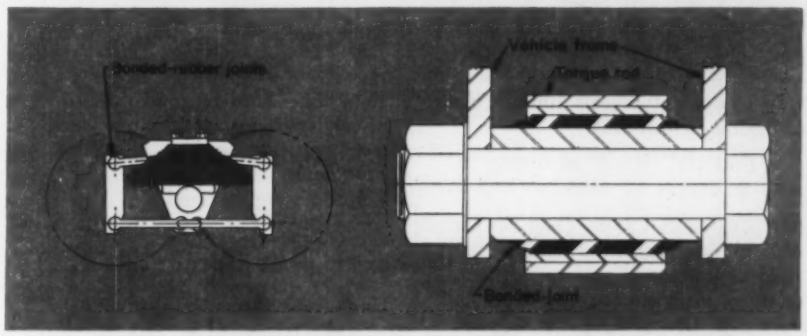
Traditionally, the designers of bulldozers, big-capacity trucks, and other earthmoving equipment have patterned their products along the lines of a solid block of steel. A stiff suspension system for wheels or tracks provides the only built-in cushion for man and machine. A quick look at all types of off-high-

## *A little play in the right places cuts down maintenance, increases equipment life . . .*

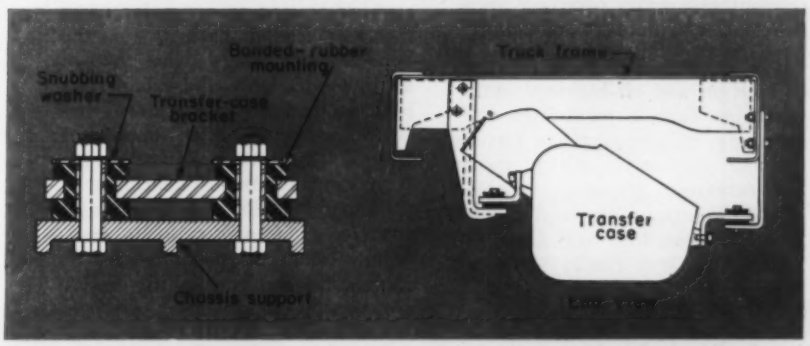
Load-equalizer beam for crawler tractors is a brand-new application for bonded-rubber mountings. The low-cost bonded assembly replaces conventional leaf-spring equalizers to cushion shock loads and isolate vibration. Mountings have desired vertical stiffness, but permit ±8-deg oscillation of the beam. The assembly requires no lubrication or maintenance.



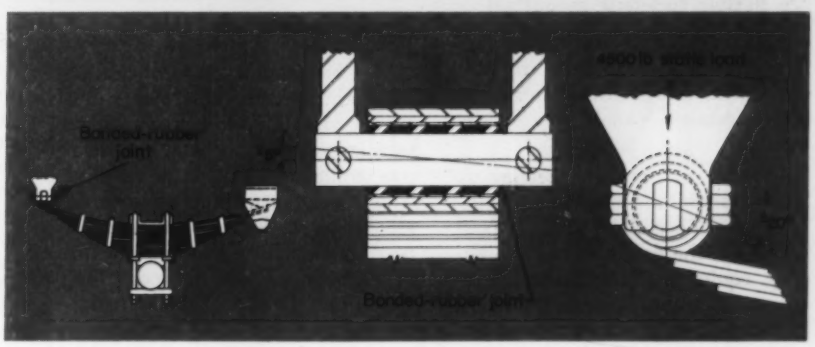

High-capacity torque-rod joints accommodate torsional and angular motion at torque-rod ends. The units withstand driving and braking loads of more than 24,000 lb and shock loads in excess of 25 tons.

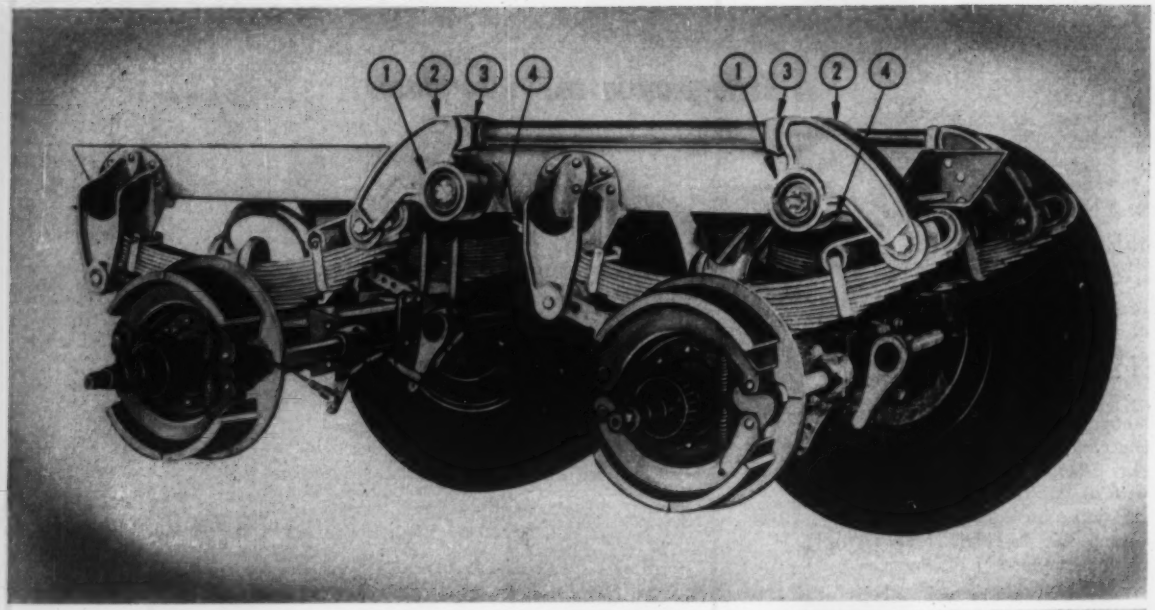



Rubber mountings for truck transfer cases withstand high torque-reaction loads, accommodate chassis twist, and prevent transmission of high-frequency noise and vibration through frame to cab. Until now, suspensions were either so stiff that noise and vibration were readily transferred, or were too soft and distorted under drive-shaft push and torque.




Flexible spring-eye joints will withstand 4500-lb static radial loads. They need no lubrication and will outlast similar metal parts.






way equipment reveals limited use of flexible suspensions:

• Engines: Rigid mounting is used in almost all vehicles.

• Transfer Cases: Over 50 per cent of off-highway vehicles use rigid mountings or stiff suspensions, causing maintenance problems or excessive noise. Properly applied resilient mountings overcome these deficiencies without loss of stability.

• Radiators: Only 50 per cent of both on and off-highway equipment use flexible mountings. Accordingly, maintenance can become a major problem as vehicle speeds are increased. It should be noted that LeTourneau has used flexible radiator mountings for about 10 years; Dart and Euclid for about 5 years.

• Fuel Tanks: Few vehicles utilize flexible fuel-tank mountings.

• Instruments: Only hour meters are flexibly mounted in most equipment. Other instruments and/or instrument panels are rigidly mounted.

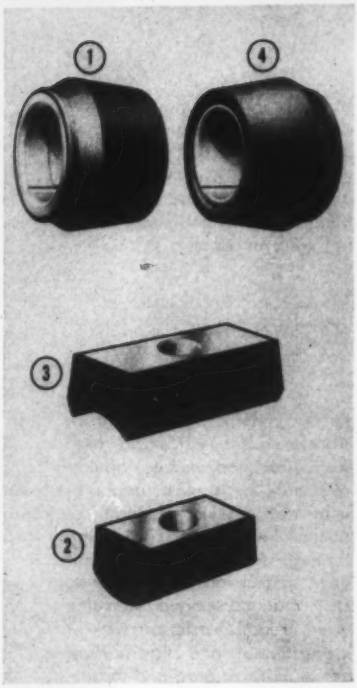
Instead of merely beefing-up frames, axles, and supports to withstand the added stress of high-speed operation, the designers of off-highway equipment are inserting resilient mountings, wherever feasible, to reduce shock, vibration, and distortion. The hardware involved is relatively inexpensive, requires little space, and can be had with the right amount of bounce for almost any specific application.

## Flexible pivot joints . . .

being introduced in off-highway equipment consist of an elastomeric element bonded to a tubular inner member. Radial capacity of the bonded assembly is twice that of an unbonded unit, and radial stiffness assures proper alignment between connected parts. The joints have a soft torsional spring rate, permitting rotational deflection of ±30 deg. Angular deflection ranges to ±7 deg. Since there is no metal-to-metal contact, the units need no lubrication and consistently outlast comparable metal parts.

## Flexible mountings . . .

are being utilized to cushion heavy shock loads, absorb high-frequency vibration, and accommodate misalignment, distortion, and relative motion without loss of stability. Their use often permits better overall design, at less cost, than could possibly be achieved by other methods. The mountings need no lubrication and give long, maintenance-free life.




Rubber-cushioned tandem needs no lubrication. The load-distributing mechanism uses 16 rubber mountings and joints to absorb shock and reduce friction. Flexible pivot joints 1 and 4 are used at trunnion ends; 2 and 3 provide a flexible joint between connecting-rod ends and load-equalizer rocker arms. Use of the bonded-rubber units provides an additional advantage: Less rigid tolerances are required in other components. The built-in flexibility readily fits space requirements in new and existing equipment, and is expected to improve the performance of new off-highway trucks and trailers.

Slots (or corrugations) prevent Fastener from turning.
Sheet remains flush on opposite side. No swaged rim projects.
Clinching ring squeezes sheet material around back-tapered shank, securely locking Fastener.

# The PEM ORIGINAL Self-Clinching Fastener

Fifteen years ago Penn Engineering and Manufacturing Company introduced the self-clinching fastener, providing load-bearing threads in a wide range of—steel, aluminum, brass and copper sheets, "too thin to thread."

### THE ANSWER TO PRODUCTION FASTENING

This unique, exclusive design was immediately recognized as the answer to production fastening by leading manufacturers of aircraft and missiles, automotive, electronic and communication equipment, business machines, farm machinery, electrical appliances, transportation equipment, vending machines, home appliances, etc. Stimulated the cost-conscious sheet metal assembly techniques utilized, today, by many of these manufacturers.

### INSTALLED BY A SQUEEZE *With the Greatest of Ease* (without special tools)

Users tell us that—because the shank of PEM nuts acts as their own pilot . . . because, being round, they require no indexing . . . because they require no special tools . . . because several may be pressed into place in a single operation

### THEY SAVE THEIR COST MANY TIMES OVER

. . . in time, labor and special equipment. That PEM nuts are one of the most profitable items in the assembly line.

Today, PEM Self-Clinching Nuts are made in six types for sheet thicknesses from .032 and up—in steel (with various rust resistant finishes), stainless steel, monel and aluminum. Sizes range from #2 to ¾". Also made as Blind Fasteners for pressure seal applications.

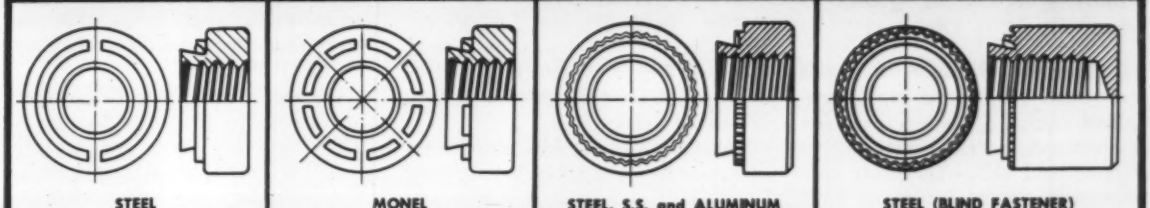
For complete information, write for Bulletin No. CL356 and sample for test.

### HIGH TORQUE AND PUSH-OUT RESISTANCE

. . . greatly in excess of assembly handling and screw torquing requirements, insure smooth, fast, uninterrupted fastening procedure. In service, under working load and vibration, torque and push-out resistance are not reliability factors, since the screw is always pulling the PEM Nut toward the sheet into which it is fastened.

The smooth *reverse* side of the sheet, with no swaged rim projecting, permits flush-tight assembly without need for clearance hole in attached part.

**SIX TYPES OF PEM SELF-CLINCHING FASTENERS ANSWER MOST ALL REQUIREMENTS**




## PENN ENGINEERING & MANUFACTURING CORP.

DOYLESTOWN • PENNSYLVANIA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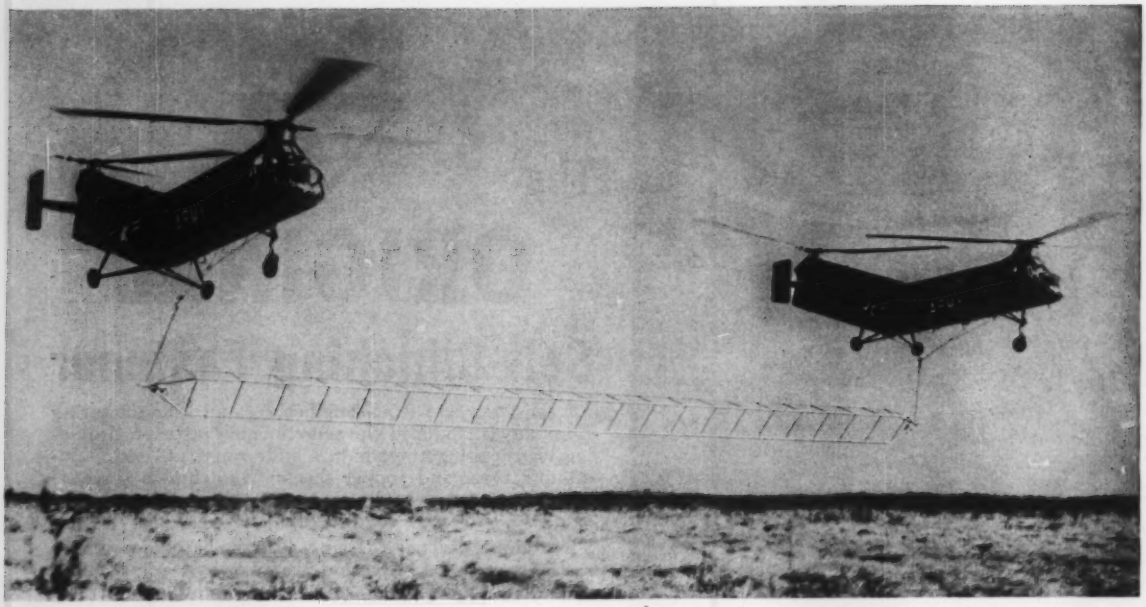
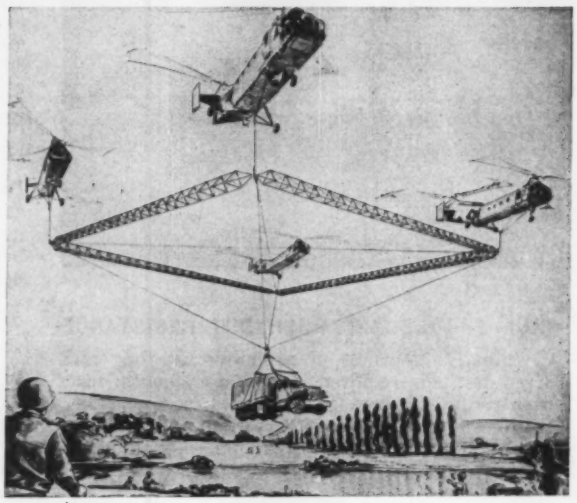


## Choppers Gang Up for Team Lift

**Teams of helicopter "workhorses"**—harnessed for a group lift by aluminum spreaders—are being groomed for Army heavy work by Vertol Aircraft Corp. Purpose of the "multiple helicopter heavy-lift system" is to speed up delivery of military vehicles to forward combat areas. Test flights by Vertol have been carried out so far with a pair of helicopters and one spreader (top). Each spreader weighs 400 lb and is long enough (113 ft) to give ample air space to each helicopter in the hitch. Later work will explore problems with three and four choppers (right). Careful work by all pilots working in a lift is, of course, an essential, and all crews will be in constant radio contact. Changes in speed, heading, and altitude are to be co-ordinated by a command pilot. In the event of an emergency, any pilot in the team can uncouple himself and all team members by means of an electrical release system. Advantages of the gang-lift system over special-purpose "flying cranes" is said to be significant: After a team organized for a lift by an Army commander has completed its job, all helicopters resume normal combat-area roles.



## Specialization Is Key Factor In Soviet Engineering Colleges

### 160 Degrees Offered, Quality Impresses U. S. Observers

Engineering education in Russia is of sound quality and highly specialized nature. This was the major observation of an eight-man mission of prominent U.S. engineering educators who returned recently from three weeks of study and inspection in the Soviet Union.

The mission was sponsored by the American Society for Engineering Education and the National Science Foundation, with the co-operation of Engineers Council for Professional Development. Its chairman was Dr. Frederick C. Lindvall, California Institute of Technology. Members of the delegation visited 25 teaching and research institutions in Moscow, Leningrad, Kuibyshev and Frunze.

According to the delegates, Soviet engineering education is narrowly specialized and prepares students to be immediately useful to industry with a minimum of additional training. This approach divides the engineering profession into some 160 separate specialties. Mechanical engineer - automobile designer and mechanical engineer-automobile maintenance, are typical specialties. Less than 20 fields are accredited in the U. S., with the great majority of students enrolled in about five fields.

Obtaining an engineering degree in Russian requires about five years. The first two years are broadly based on mathematics and science. But from the day of his matriculation the student pursues a specialty. Problems in all major subjects are selected to emphasize their application to his field.

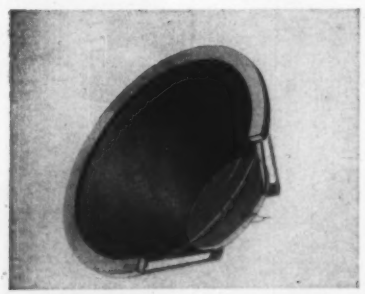
The last three years consist of in-

creasingly specific courses, often built around design projects, industrial practice, and an elaborate diploma project requiring one semester of full-time work. These projects involve extensive detailed drawing and are intended to acquaint the student both with principles and prevailing practices in his specialty.

The young Soviet engineers are well grounded, and their best men are as good as any in the world. However, it appears to the delegation that many must be limited in their outlook since they know little engineering outside their own narrow field.

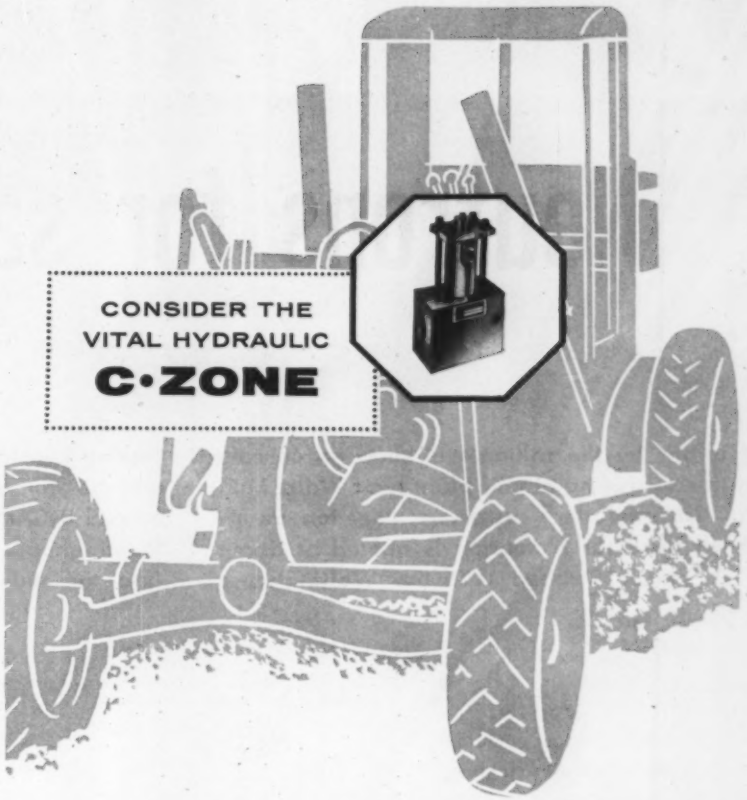
The delegation also noted that nowhere is the engineer and scientists held in higher regard than in the U.S.S.R. Engineering students and practicing engineers are exempt from military service and are among the aristocracy of Soviet society. There is, naturally, strong motivation and social pressure to aspire to such careers.

A motivation factor not to be underestimated is the strong devotion to a system that greatly encourages education. Those who qualify for admission to an institution of higher learning need not be concerned because of a lack of financial resources.



### *Wafer Replaces Speaker Magnet*

**Heavy iron-core magnet and voice coil of conventional loudspeakers are replaced by a thin disc** at the apex of the speaker cone in this experimental speaker developed by Mullenbach Div., Electric Machinery Mfg. Co., Los Angeles. Two electrostrictive barium titanate wafers sandwiching a 1½-in. diam titanium diaphragm make up the disc. Cupping of disc due to electrostrictive action of the wafers drives the speaker cone. Other applications for the transducers include nonmagnetic switches, rapid-acting relays in computers and compact metering manometers (MD, Dec. 11, 1958, p. 12).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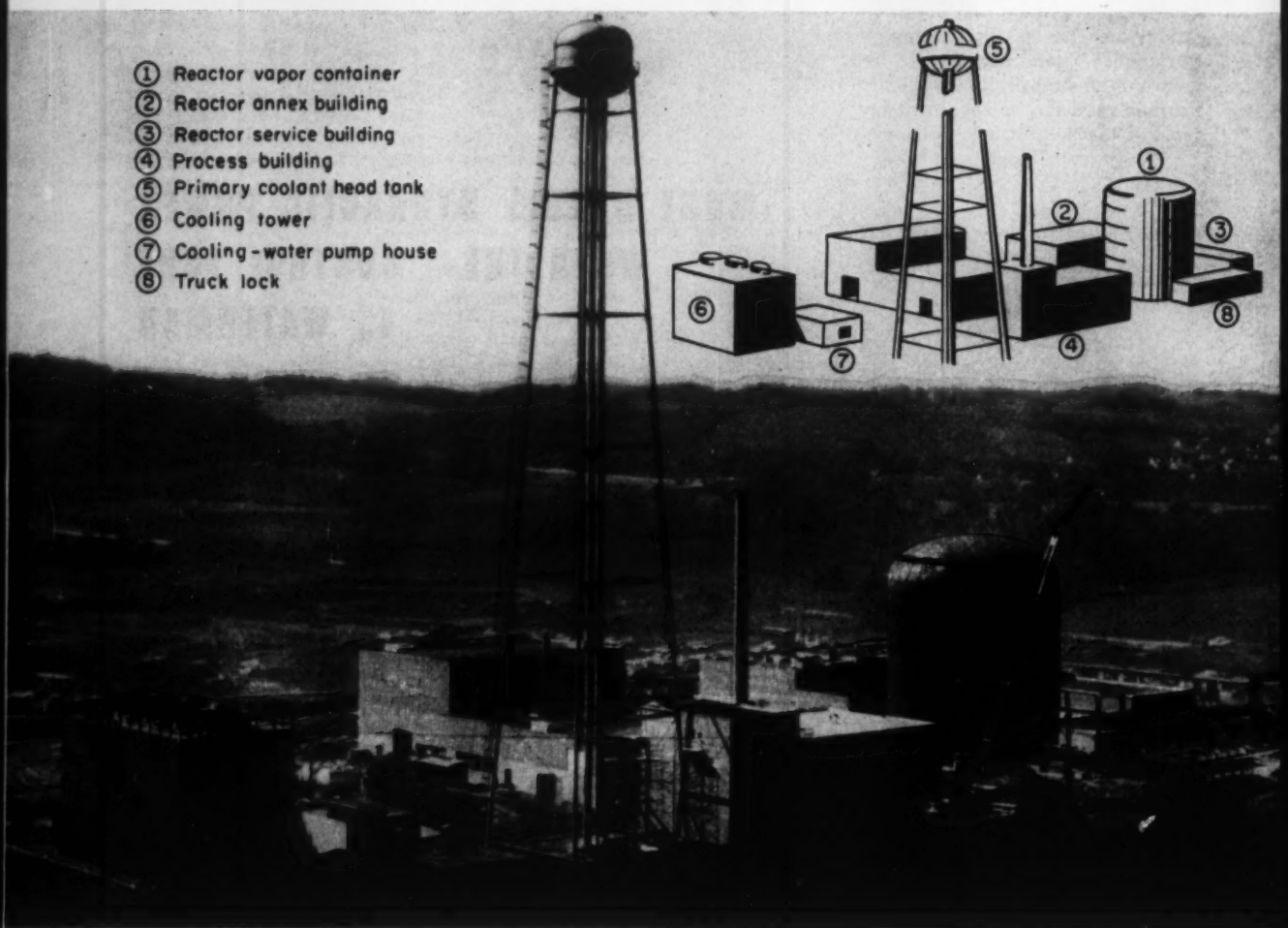
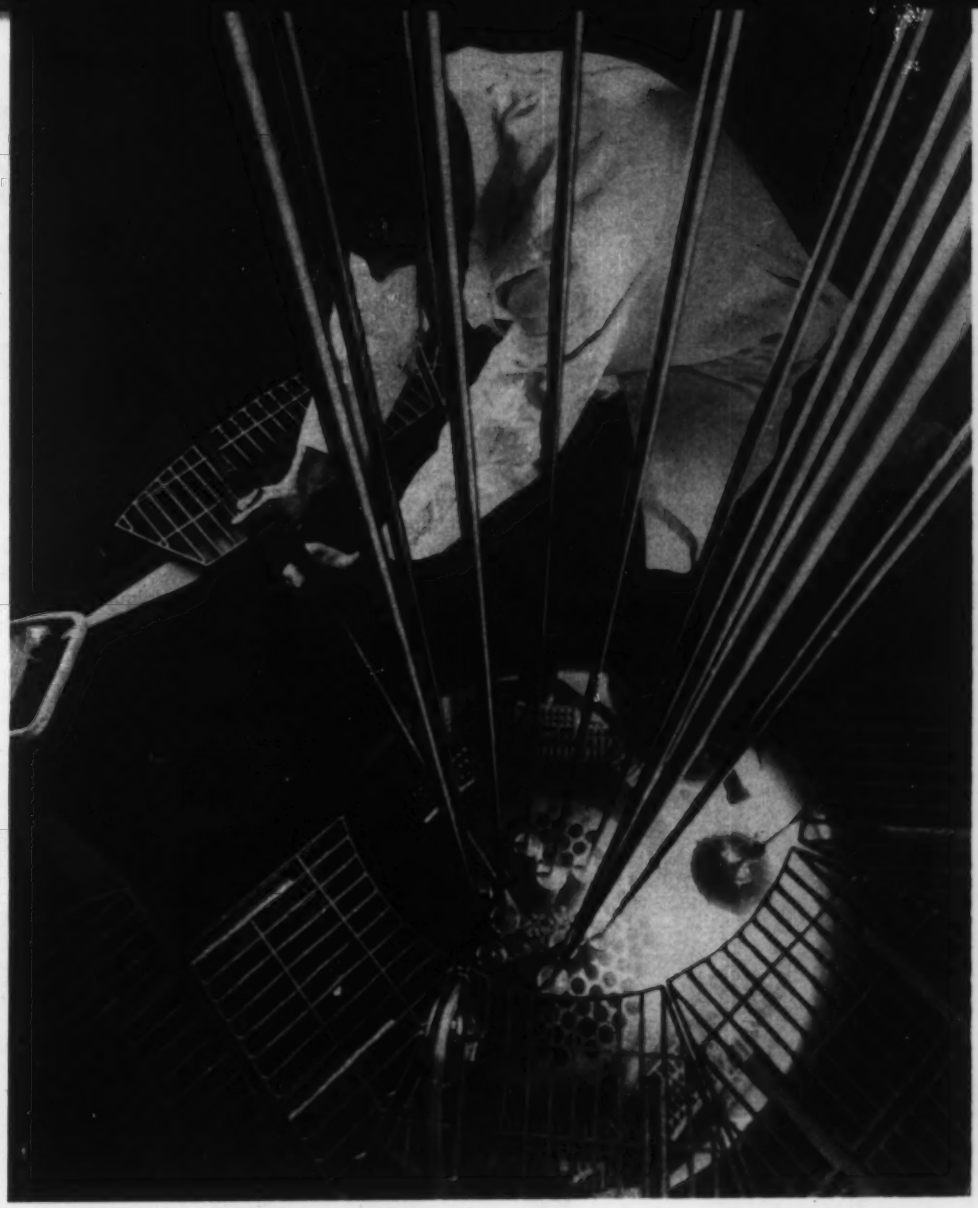
Circle 415 on Page 19

# Neutrons for sale

**Neutrons by the trillion will soon go on sale at this sprawling atomic plant near Waltz Mill, Pa. To interested customers, the tongue-in-cheek price for a neutron is quoted at about $\$10^{-20}$ each. Dubbed WTR (for Westinghouse Testing Reactor), the $10 million research tool will be the first materials-testing reactor not owned by AEC. WTR's biggest task is to help Westinghouse and its neutron "customers" find the way to economical nuclear power.**

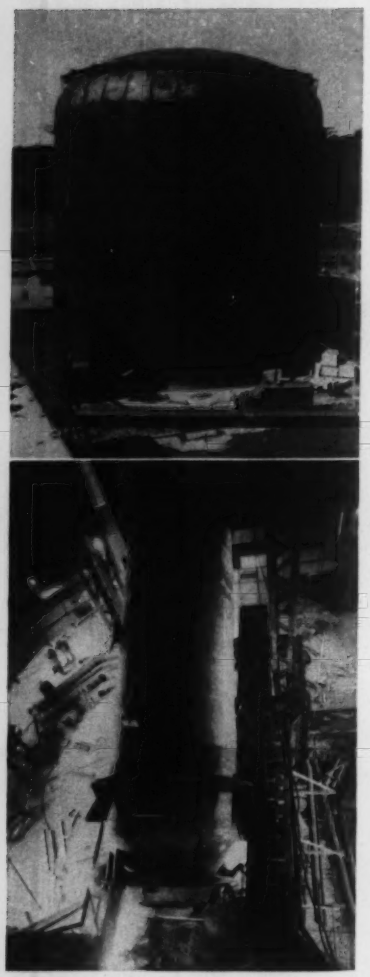




**Heart of the Westinghouse Testing Reactor** will be this 44-in. diam core structure, here shown under test at the Critical Experiment Station in Waltz Mill. In "critical" operation since June, the active core is nominally loaded with 60 or more U-235 enriched fuel elements assembled in three concentric cylinders. Rising above the core are extensions on control rods that govern rate of nuclear reaction. The test program now underway gives Westinghouse scientists a practical check on theory that went into the WTR design.

AN ATOM-AGE QUIP is making the rounds at Westinghouse's new materials-testing reactor. Referring to an estimated 1.5 million tons of coal under the 850-acre Waltz Mill property, WTR scientists say that it's their "basic asset," one not to be touched until usefulness and worth of the fossil fuel are rediscovered in years to come.

But in the meantime, WTR will work hard at its primary job of solving fuel and material problems which must be solved if economic nuclear power is to become a reality. Before WTR, there were only three testing reactors in this country: The Materials Testing Reactor (MTR), the Engineering Testing Reactor (ETR), and the Oak Ridge Research Reactor (ORR). All three are owned by the Atomic Energy



**Housing the 44-in. diam core of WTR** is a mammoth 85-ft high, all-steel vapor container (top). When the reactor is in operation, air in the container will be changed once every four minutes. Any leakage will be inward, since air pressure in the container will be slightly lower than atmospheric. Photographed from the inside ceiling of the vapor container, the reactor pressure vessel (bottom photo), soon to be water flooded under a 240-ft head, is shown being tilted to an upright position. High-density concrete shielding, 7½ ft thick, will protect personnel from intense radiation generated by the reactor core.

Commission.

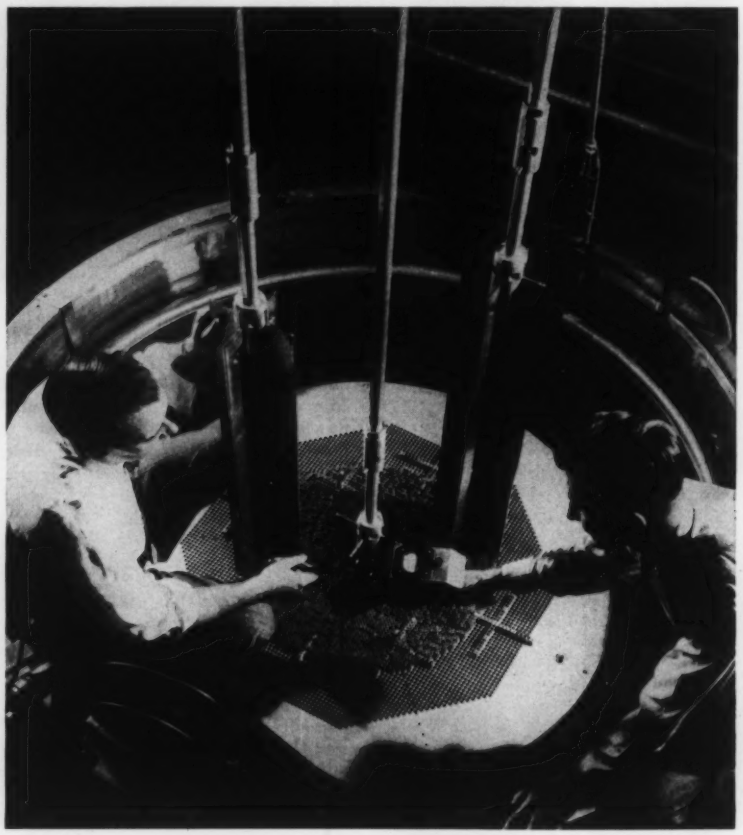
According to E. T. Morris, manager of WTR, "The AEC has repeatedly stated the need for additional research and testing reactors, and have urged private industry to build them." Besides solving its own problems, Westinghouse plans to fill the demand from industry for testing-reactor space not available in government units.

Early work is cut out for WTR. Characteristics of the many types and forms of nuclear fuel must be determined, particularly their stability in relation to allowable burnup and the temperature at which burnup occurs. "In general, the higher the burnup and the higher the burnup temperature, the lower the cost per unit of power," says Mr. Morris.

The in-pile irradiation facilities at WTR will also give insight into problems such as embrittlement, cracking, and corrosion associated with reactor structural and control materials that are subjected to high neutron fluxes and temperatures.

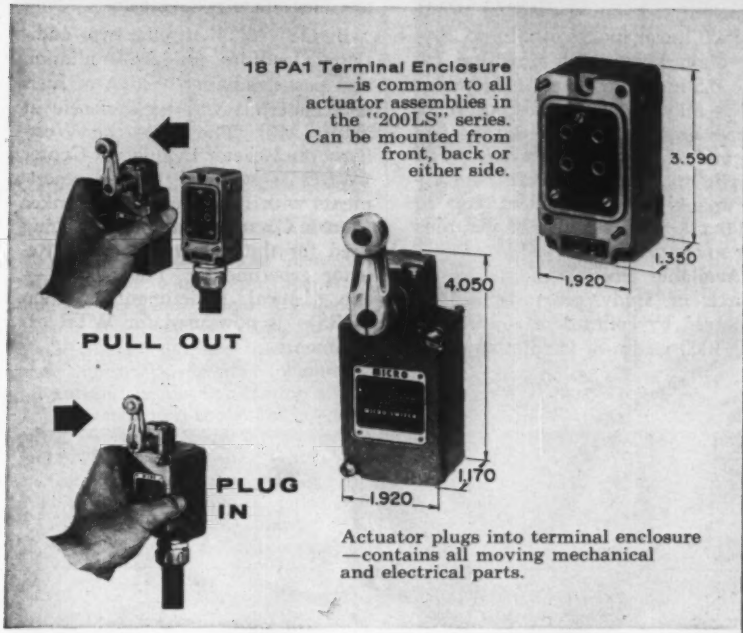
At the center of WHR's 7-acre complex of laboratories and support buildings is the 20-megawatt (thermal) reactor. Moderated by ordinary water, the reactor is cooled by water flowing at a 13,660 gpm rate from a head tank, towering 240 ft over the site. Water enters the reactor pressure vessel at 115 F and leaves at 125 F. Should the demand arise, reactor power level can be raised to 60 megawatts with minor modification to buildings and equipment.

Prominent feature at the site is the all-steel vapor shell, 85 ft high by 70 ft in diameter, that surrounds the reactor pressure vessel. WTR is unique in having a water-filled canal—100 ft long and 18 ft deep—to provide a continuously shielded connection between the reactor itself and three hot-laboratory caves where irradiated specimens can be examined. The canal contains a power-driven carriage to permit movement of experimental material,



**Cutie-Pie—a radiation monitoring instrument**—is here being used at WREC to measure radioactivity of one of the 3000 fuel rods in a core like that designed for the Yankee Atomic Electric Co. nuclear-reactor plant. WREC, the Westinghouse Reactor Evaluation Center, is another facility for atomic research at the Waltz Mill tract.

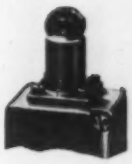
# MICRO SWITCH Precision Switches


18 PA1 Terminal Enclosure —is common to all actuator assemblies in the "200LS" series. Can be mounted from front, back or either side.
3.590
1.350
1.920
4.050
1.170
1.920
PULL OUT
PLUG IN
Actuator plugs into terminal enclosure —contains all moving mechanical and electrical parts.

**201LS3 Adjustable Arm Rotary Actuator**—roller lever arm is adjustable to any point in a 2½-inch range. Head assembly can be positioned to any of 4 sides of switch. Actuating direction and operating point are adjustable.

**208LS1 Coil Spring Actuator**—flexible spring actuator for multi-direction operating motion

**201LS10 Rod Actuator**—provides light actuating force. See adjustability details under 201LS1 below



**205LS1 Roller PlungerActuator**—adjustable at 90° angles

**202LS1 Push Plunger Actuator**—for in-line actuating motion

**201LS1 Roller Arm Actuator**—field adjustable for actuation clockwise, counter-clockwise, or in both directions. Arm is adjustable through 360°. Head can be faced in any of four directions.

## Sealed "Plug-in Limit" Switch cuts costly downtime

*Compact sealed enclosures with choice of 6 actuators meet wide range of industry needs*

Here's a precision limit switch that can be replaced complete in 20 seconds! Downtime is all but eliminated!

The switch enclosure of this new "Plug-in Limit" switch, in any of six actuator styles, plugs into the terminal enclosure like a radio tube . . . is precisely positioned by dowel pins and secured by two No. 10 screws. Together, the two parts form a complete unit, sealed against oil, water, dirt and dust.

The "Plug-in Limit" is two-circuit double throw. Electrical rating is 10 amps. 120, 240, 480 vac; ½ H.P. 120 vac; 1 H.P. 240 vac; 0.8 amp. 115 vdc; 0.4 amp. 230 vdc; 0.1 amp. 550 vdc. Pilot duty rating is 600 vac max. Meets NEMA Industrial Control Standards.

For details of the "200LS" series, write or call the MICRO SWITCH branch office near you, or send for Catalog 84.

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Circle 416 on Page 19

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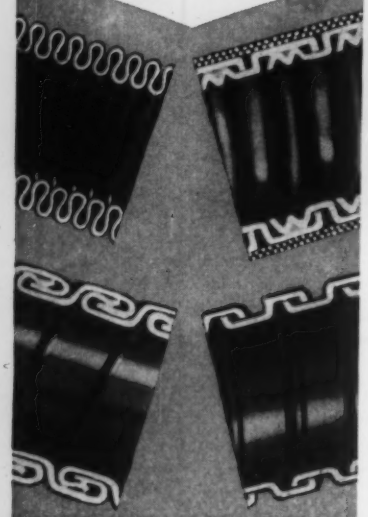


PENFLEX
TIGHT AS A PIPE BUT...
FLEXIBLE

Circle 417 on Page 19

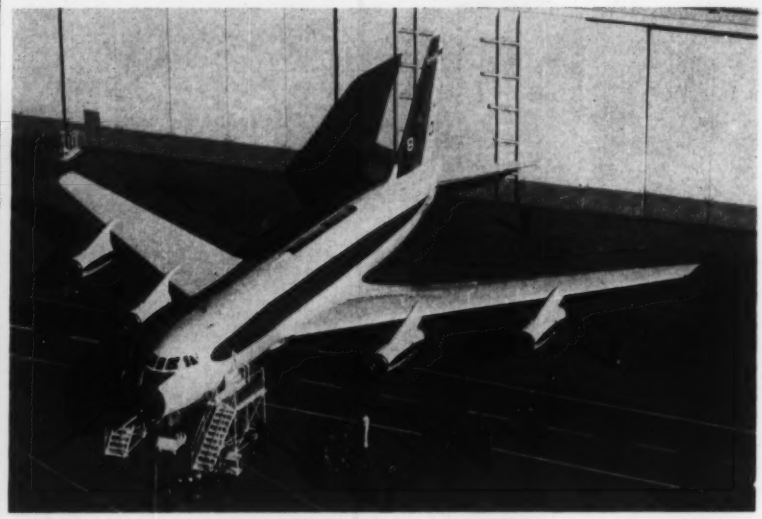


spent fuel elements, etc., along its full length.

In-pile irradiation space at WTR is 5500 linear inches of 1-in. to 2½-in. diam holes, with provision for one 6.5-in. diam hole. Five rabbit tubes allow short-term exposure of materials for periods less than the normal 25-day reactor cycle. The in-pile space will accommodate experiments in environments up to 2000 psi, 625 F, and $10^{14}$ neutrons per sq cm per sec.

Available free of charge to research or study programs wholly financed by colleges or universities are 3000 cu in. of irradiation space in the flux range of $10^{12}$ to $10^{13}$ neutrons per sq cm per sec. Westinghouse will also offer co-operative summer programs for nuclear study to college faculty members.

Besides WTR itself, two additional facilities for pre-irradiation and post-irradiation testing of fuels and materials will be available at Waltz Mill. The first—the Westinghouse Reactor Evaluation Center (WREC)—was first used for experiments with the core of the Yankee Electric Co. reactor and is now being used for the Belgian Thermal Reactor experiments. The second — the Critical Experiments Station (CRS)—is now used for WTR experiments.



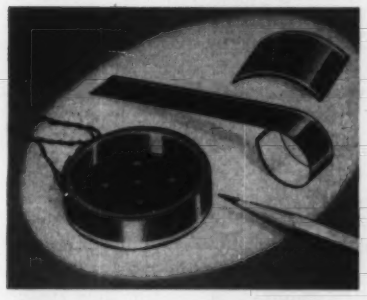
## Mach 0.9 Airliner Beats Schedule

**Convair's 615-mph, medium-range jet airliner rolls off the line in San Diego, Calif., two weeks ahead of schedule.** Four engines, which are commercial versions of the GE J-47, give the 880 a ceiling of 40,000 ft and a range of 3250 miles when carrying 88 passengers. After exhaustive ground tests, the 178,500-lb airliner will make its maiden flight in six to eight weeks carrying ballast tanks and instruments. Delivery to airlines is expected about next November.

## Pocket Radio-phone OK for Civilian Small Talk

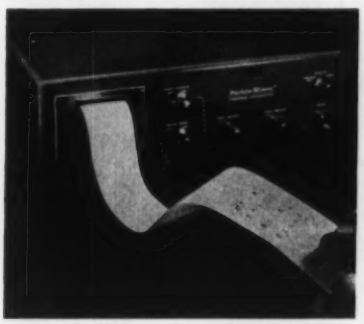
NEW YORK — "Citizens' band" of frequencies, recently designated by FCC for nontechnical civilian communication, is used by a compact two-way radio developed by RCA. Personal conversations are permitted, and the operator needs only an easily secured license. Aside from licensing requirements, the phone differs from an earlier announced RCA police radio in being easier to operate and less expensive.

Radio-phone weighs less than 10 lb.; it operates from 6 or 12 v batteries, or from a standard 115-v ac power source. Set measures 9 in. high by 7 in. wide by 5 in. deep. Small-boat enthusiasts, hunters, farmers, and drivers are expected to find use for the unit. Price: about $100.



## Photocell Peeks Around Corners

**A pliable, selenium-based photocell bends around to spot light changes in that hard-to-get-at corner.** Developer, International Rectifier Corp., El Segundo, Calif., suggests uses as nonlinear function generators (photo-sensitive cam), or position-control servos (cell mounted on a shaft). The cell also offers more flexibility in design of burglar-alarm components, door openers, cameras, and automatic equipment where photocell units are housed. It can be molded to almost any shape as long as a minimum radius of curvature of 1 in. is observed.



## Integrator Prints Digital Sums

**Area summation under strip-chart recorder plots are printed out automatically by a digital integrator** developed by Perkin-Elmer Corp., Norwalk, Conn. Printer actuates whenever recorder pen reverses direction (max or min). Integrals are printed on adding-machine tape traveling at the same speed as the plot chart; tape and chart records may be laid side by side for comparison. Area under any curve segment may be obtained by subtracting successive integrals corresponding to the beginning and end of that segment. At a chart speed of ½ in. per min, the integrator makes 1263 counts per square inch of chart. Manufacturers of the integrator foresee its use in continuous-process weighing, integration of rocket thrust, and stress-strain curves.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Circle 418 on Page 19

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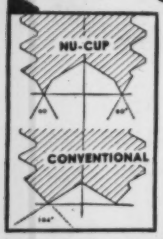


Setko Slabbed Head Set Screws are real money savers. They cost less than comparable hexagon or fluted socket set screws, yet they take greater tightening pressures... Up to 50% more torque without damaging.

Holding power can be even further increased when furnished with Setko's own NU-CUP, the patented holding cup point that has a 42% sharper cutting angle. Cuts are deeper and in a full circle.

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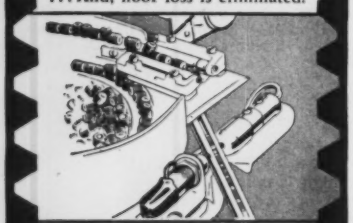

SEND FOR FREE SELECTOR CHART of Self-Locking Set Screws

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Circle 419 on Page 19




## *Plastic Beads, Aluminum Sheet Form Strong, Lightweight Panel*

### Weight Saving in a Typical Refrigerator: 150 lb

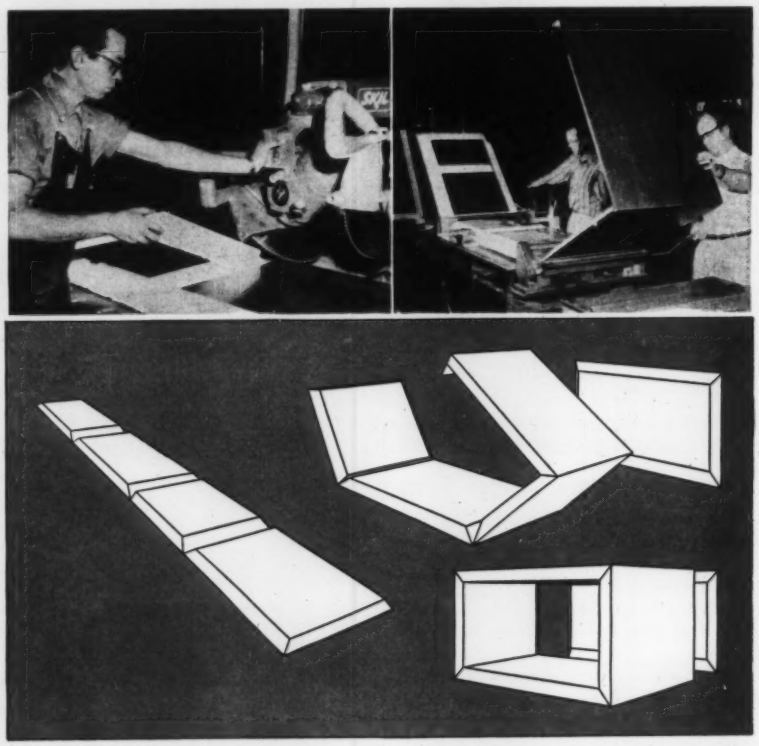
PITTSBURGH — A remarkable new panel material, made of aluminum sheet and foamed plastic beads, offers design simplicity, light weight, high strength, efficient insulation, and economical workability all wrapped up in one package. Developed by Aluminum Co. of America, and called Alply, the unique material is already being used in new Westinghouse refrigerators.

Alply's core material consists of expandable polystyrene beads. The beads form a white, opaque, and odorless foam material which has no food value for plant or animal life, and is nontoxic and self-extinguishing. The aluminum skin is bonded to the core with an odorless rubber adhesive.

Finish possibilities for the skin are almost limitless. It can be textured, formed, and colored by a variety of methods.

Versatility of the panel is further enhanced through the use of facing materials other than aluminum. Skin possibilities include plywood, asbestos board, and hardboard.

Possible uses for the new material appear to be limited only by the imagination—and so far its advantages are significant. The Westinghouse refrigerators, for example, are said to be lighter and more efficient than any current models. They promise drastic cost reductions when fabricated on production-line basis. Use of the panel has required only simple production tooling, permitting unusual flexibility in refrigerator design.

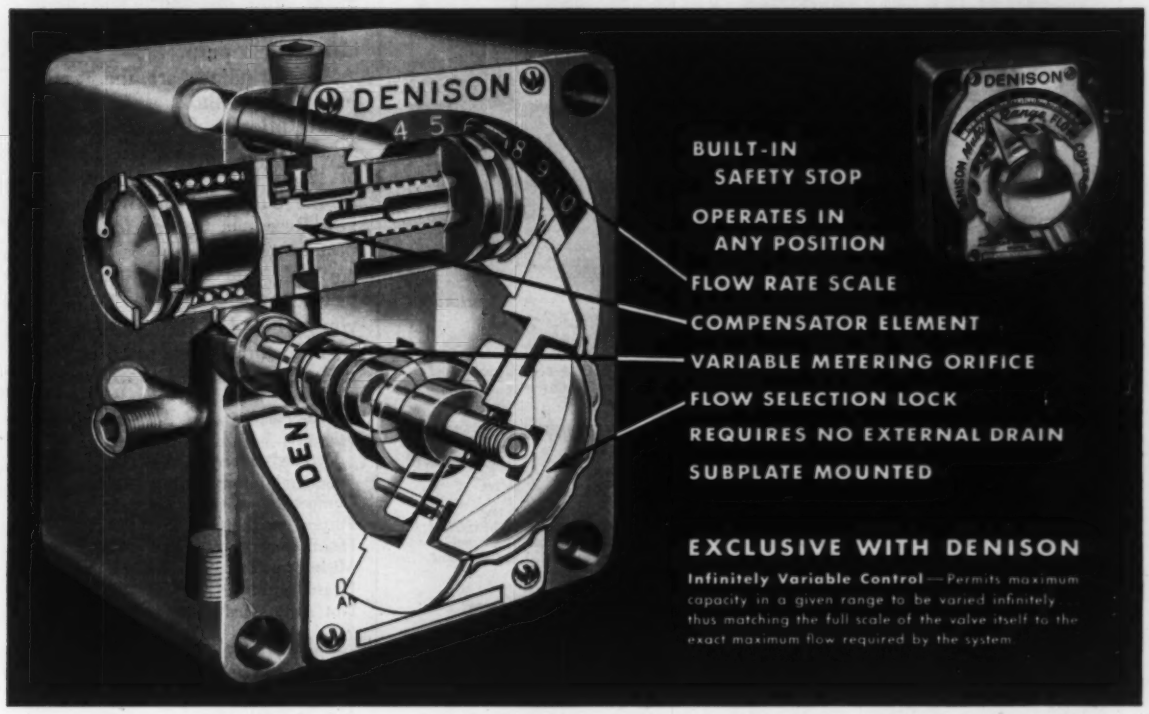


**Building a refrigerator cabinet** is about as simple as cutting out paper dolls with a new aluminum-plastic panel developed by Alcoa. Top-side-bottom-side panels are first cut to the proper rectangular shapes, then mitered and notched with a high-speed radial-arm saw. Hole drilling and routing are easily done with hand tools. Panels are then folded at the miters, and polyurethane foam is applied to joints. Final assembly begins by fastening extruded aluminum frame pieces to the face of the cabinet. Since tooling costs are cut drastically, short-run production of limited-edition refrigerators becomes economically feasible, and design obsolescence is almost a practical reality.

NEW precision FLOW CONTROL at production prices

# MULTI-RANGE FLOW CONTROL

- **extra-sensitive flow control adjustment for precise flow settings**
- **temperature-viscosity compensated...no change in selected flow rate**
- **important exclusive design features now in all 3 sizes...¼"–⅜"–¾"**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OPERATES IN ANY POSITION
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REQUIRES NO EXTERNAL DRAIN
SUBPLATE MOUNTED
EXCLUSIVE WITH DENISON
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**FLOW SURGE OVERTRAVEL VIRTUALLY ELIMINATED**—by simple adjustment—to avoid erratic feed of slides as the valve finds its setting.

**BUILT-IN RELIEF VALVE** saves space... simplifies circuits... may be remotely controlled.

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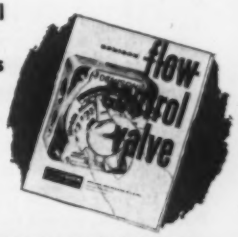


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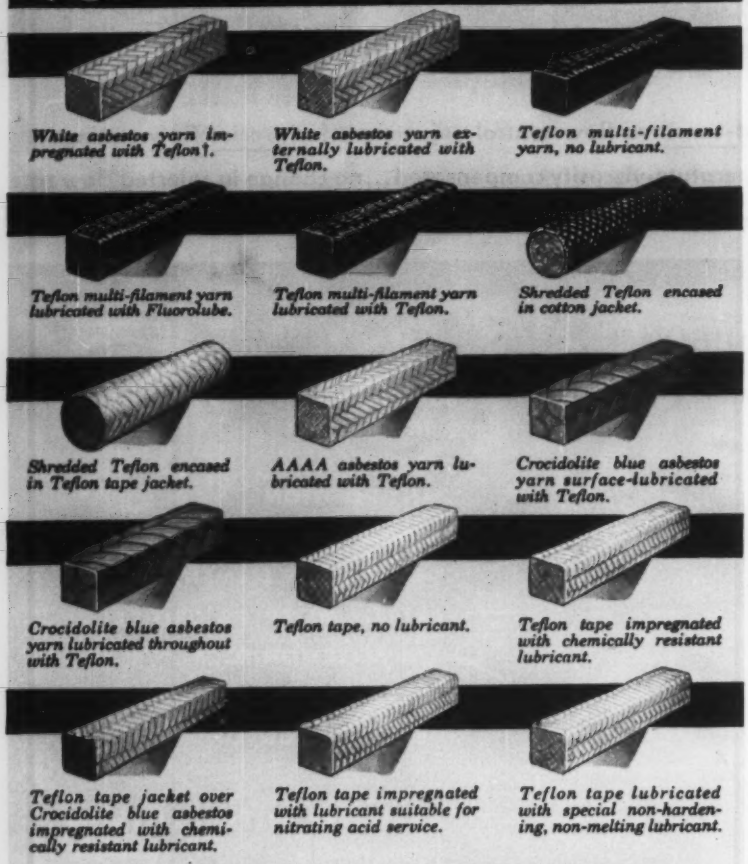
# 15 SPECIFIC PACKINGS FOR ALL CORROSIVE SERVICES



*White asbestos yarn impregnated with Teflon†.* *White asbestos yarn externally lubricated with Teflon.* *Teflon multi-filament yarn, no lubricant.*

*Teflon multi-filament yarn lubricated with Fluorolube.* *Teflon multi-filament yarn lubricated with Teflon.* *Shredded Teflon encased in cotton jacket.*

*Shredded Teflon encased in Teflon tape jacket.* *AAAA asbestos yarn lubricated with Teflon.* *Crocidolite blue asbestos yarn surface-lubricated with Teflon.*

*Crocidolite blue asbestos yarn lubricated throughout with Teflon.* *Teflon tape, no lubricant.* *Teflon tape impregnated with chemically resistant lubricant.*

*Teflon tape jacket over Crocidolite blue asbestos impregnated with chemically resistant lubricant.* *Teflon tape impregnated with lubricant suitable for nitrating acid service.* *Teflon tape lubricated with special non-hardening, non-melting lubricant.*

John Crane CHEMLON *BRAIDED PACKINGS

Specific service conditions are always best handled with a packing designed for the purpose. This is especially true when it comes to hard-to-handle liquids in pumps, valves, agitators, mixers, plating equipment and similar applications.

For this reason John Crane has developed 15 individual field-proved types of Chemlon Braided Packings. Within this line there is a type and style that will meet any combination of service conditions and requirements.

1. All known industrial acids, alkalis or solvents.
2. Temperatures from −120°F to +600°F.
3. High or low shaft speeds, also valve stems.
4. Longer packing life due to lower coefficient of friction and non-raveling construction.

Send in your service condition and we will recommend a Chemlon Braided Packing best suited to your application. Request Bulletin P-325.

Crane Packing Co., 6425 Oakton St., Morton Grove, Ill. (Chicago Suburb).
*In Canada: Crane Packing Co., Ltd., Hamilton, Ont.*

†*T. M. for DuPont Teflon* *T. M. for the Best in DuPont Teflon

John Crane MECHANICAL PACKINGS SHAFT SEALS TEFLON PRODUCTS LAPPING MACHINES THREAD COMPOUNDS

CRANE PACKING COMPANY




## Public Up in the Air About Satellites' Purpose

WASHINGTON, D. C.—Six months after the launching of Sputnik I, half the American public thought of satellites in terms of scientific achievement or competition with Russia. One-fifth viewed them in the light of future possibilities such as space platforms or trips to the moon, and one-third had only a vague idea, misinformation, or no idea of their purpose.

These findings are the result of interviews with a group of 1900 adults prior to Sputnik I and another group of 1500 in the spring of 1958. The study was conducted by the University of Michigan Survey Research Center for the National Association of Science Writers and New York University. Interviewees were asked, "From what you've heard, what is the purpose of launching these satellites?" Replies were classified as follows:

| Satellite Purpose | Before Sputnik | After Sputnik |
|---|---|---|
| Scientific: | | |
| Detailed information | 12% | 11% |
| General information | 8 | 16 |
| Competition with Russia | 1 | 20 |
| Future possibilities | | 17 |
| Heard something, vague | 14 | 23 |
| Misinformation | 11 | 4 |
| Heard nothing | 54 | 8 |
| Not ascertained | | 1 |

Educational background was found to be related to awareness and knowledge of satellites. Misinformation, however, was present at all levels. One interviewee—perhaps more mischievous than misinformed—said he thought the purpose of satellite research is to send foreign aid to the moon.

## Army Wants Weapons Now

WASHINGTON, D. C.—To get weapons off the drawing boards and into the hands of troops faster, the Department of the Army is looking critically at its development procedures. New regulation AR 705-5 is aimed at cutting time by revising existing techniques in these areas:

- Establishment of military characteristics
- Assignment of priorities

- Testing sequence (overlapping or combining tests)
- Use of standard commercial parts
- Communications and visits on R and D matters

Today's rapidly accelerating pace of scientific achievement and the competitive position of Russian technology combine to make imperative the streamlining of the military development program according to General Arthur G. Trudeau, Chief of Army Research and Development. "No step is sacrosanct or immune to improvement," says General Trudeau.

# Meetings

AND EXPOSITIONS

Feb. 3-5—

**Society of the Plastics Industry Inc.** Fourteenth Reinforced Plastics Conference to be held at the Edgewater Beach Hotel, Chicago. Additional information is available from SPI headquarters, 250 Park Ave., New York 17, N. Y.

Feb. 15-19—

**American Institute of Mining, Metallurgical, and Petroleum Engineers.** Annual Meeting to be held at the St. Francis Hotel, San Francisco. Further information is available from AIME headquarters, 29 W. 39th St., New York 18, N. Y.

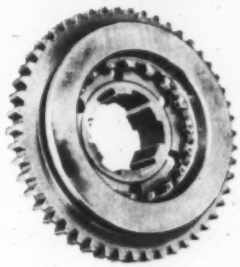
Feb. 26-March 1—

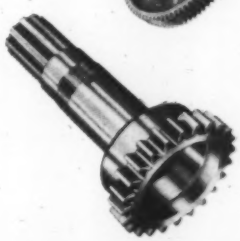
**Third Annual Engineering Exposition** to be held at the Electric Bldg., Balboa Park, San Diego, Calif. Exposition is sponsored by 28 technical societies, including American Institute of Electrical Engineers, American Rocket Society, American Society of Mechanical Engineers, Institute of Radio Engineers, Society of Automotive Engineers, and Society for Experimental Stress Analysis. Further information is available from D. H. Stewart, Chairman, Special Projects Committee, 422 Land Title Bldg., San Diego 1, Calif.

(*Please turn to Page 40*)


There is only ONE Best Gear Design for each application

... and SIER-BATH manufactures it into your gears





Sier-Bath serves you with the best gear design, engineering and manufacturing service. You get free engineering consultation and the finest gears to meet the increased requirements of tomorrow.

Sier-Bath designed and manufactured gears give you the same operating advantages that have brought leadership to many other machinery manufacturers.

Sier-Bath continues to give you
PRECISION CROWN-GROUND SPUR AND HELICAL GEARS
to 12" diameter, 4 pitch

Send us your gear prints or specs for study and quotation—or have a Sier-Bath gear specialist call to discuss the steps that will make us your ideal gear department.

Sier-Bath PRECISION GEARS

All kinds of gears—all materials.
Made—cut—shaved—ground tooth.
48" maximum diameter
12 or more of a kind, depending on size

Sier-Bath GEAR & PUMP CO., Inc.
9237 HUDSON BOULEVARD NORTH BERGEN, N. J.
Founded 1905 Members A.G.M.A.

Also manufacturers of Rotary Pumps and Flexible Gear Couplings




Circle 422 on Page 19 Circle 423 on Page 19→

What
the
designer
conceives...
aluminum
achieves!

Aluminum screw machine knobs—economical and versatile for your high quality products—offer designers infinite control panel styling possibilities both for shape and for color.

In finished shapes such as the examples shown, aluminum gives sharp, clean lines... unusually fine "as machined" finish... plus the quality feel of solid metal. Low tooling cost, particularly as compared to die casting or stamping dies, adds not only initial economy but model-change versatility as well.

And for the brilliant beauty of any color, these knobs take permanent finish by one-step anodizing—usually at far less cost than chrome plating or similar plated surfaces. Aluminum offers still more useful properties, such as light weight with high strength, corrosion resistance, non-sparking and non-magnetic qualities.

If you would like design details for the parts shown here, complete with cost and production data, please send in the coupon below.

(Kaiser Aluminum does not manufacture screw machine parts, but does offer technical assistance to parts suppliers throughout the country. Contact your local screw machine products manufacturer for further information and quotations on specific parts in aluminum.)

KAISER ALUMINUM

THE BRIGHT STAR OF METALS





☐ PLEASE CALL

☐ PLEASE TELEPHONE

☐ Please send booklet showing design details and cost-production data for parts illustrated in ad.

NAME

COMPANY

ADDRESS

CITY STATE

MAIL TO | Advertising Dept. SM-944
KAISER ALUMINUM & CHEMICAL SALES, INC.
919 N. Michigan Ave., Chicago 11, Illinois

*Show us how we may best serve you...*

# WHERE CAN YOU USE CERAMIC MAGNETS?

The remarkable permanence of Stackpole Ceramagnet Permanent Magnets is, of course, a main reason for their use. *(Ceramic magnets have the highest coercive force of any commercially used magnet materials!)* There are, however, many other reasons of almost equal importance as outlined in the following table.

| APPLICATIONS | CERAMAGNET ADVANTAGES |
|---|---|
| **MECHANICAL (Holding)** | Maximum permanency . . . Availability because of non-critical materials . . . Can be magnetized **before** or **after** assembly . . . Keepers or pole pieces not needed . . . Full energy usable without auxiliary leakage gaps . . . Maximum economy in large sizes or odd shapes . . . Inert to most chemicals and gases . . . Provides greater pull from a distance. |
| Such as LATCHES, DOOR CLOSERS, TOYS, NOVELTIES, COUPLINGS, CONVEYORS, SEALS, HOLDING ASSEMBLIES AND FIXTURES, and others. | |
| **MECHANICAL (Dynamic) & PM FIELDS** | High coercive force . . . May have up to 8 poles on a face (avoids need for costly unusual shapes) . . . Stronger, more permanent driving torques . . . Lighter weight . . . Permit use of shorter, more favorable shapes . . . Magnetizing before assembly eliminates complicated fixtures . . . No permanent energy loss from air gap changes . . . Can be used in strong magnetic fields . . . Low cost in odd shapes. |
| Such as MAGNETIC DRIVES, RELAYS, D-C MOTOR FIELDS, ROTORS, MAGNETOS, SMALL GENERATORS, PHONO PICK-UPS, CIRCUIT BREAKERS . . . and similar equipment. | |
| **ELECTRONIC and POLARIZING** | Maximum coercive force . . . Almost infinite electrical resistivity . . . Highly resistant to demagnetization by driving field . . . Negligible eddy current losses . . . Less heating . . . Unaffected by strong magnetic fields . . . Easily designed for simplified holding fixtures . . . Often practical in more favorable shapes for equipment design improvement. |
| Such as MAGNETIC FOCUSSING OR DEFLECTION OF CATHODE BEAM TUBES . . HIGH FREQUENCY ALTERNATORS . . ION TRAPS . . SONAR DEVICES . . TRANSDUCERS . . LOUDSPEAKERS, etc. | |
| **MISCELLANEOUS** | Non-conductors . . . Do not cause unwanted current paths when placed close to circuit-interrupting equipment. . . . Simplify equipment design . . . Linear energy variation and retrace with temperature increase and decrease. |
| Such as LIGHTNING ARRESTERS, ARC SNUFFERS, TEMPERATURE-SENSITIVE DEVICES, and other equipment. | |

WRITE for Ceramagnet Bulletin RC-11A.

STACKPOLE CARBON COMPANY, *St. Marys, Pa.*

**STACKPOLE** *CeraMAGNET*®

THE PERMANENT MAGNETS THAT ARE REALLY PERMANENT




(*Continued from Page 37*)

**March 3-5—**

**Western Joint Computer Conference** to be held at the Fairmont Hotel, San Francisco. Institute of Radio Engineers, American Institute of Electrical Engineers, and the Association for Computing Machinery are sponsors. Additional information can be obtained from Richard W. Melville, Stanford Research Institute, Menlo Park, Calif.

**March 9-10—**

**Steel Founders' Society of America.** Annual Meeting to be held at the Drake Hotel, Chicago. Additional information is available from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

**March 11-13—**

**Pressed Metal Institute.** Spring Technical Meeting to be held at the Pick-Congress Hotel, Chicago. Further information can be obtained from PMI headquarters, 3673 Lee Rd., Cleveland 20, Ohio.

**March 31-April 2—**

**21st American Power Conference** to be held at the Hotel Sherman, Chicago. Conference is sponsored by Illinois Institute of Technology, in co-operation with 9 technical societies and 13 other educational institutions. Additional information can be obtained from R. A. Budenholzer, Mechanical Engineering Dept., Illinois Institute of Technology, 3300 Federal St., Chicago 16, Ill.

*"Why don't you get new glasses?"*



Circle 424 on Page 19

Circle 425 on Page 19→

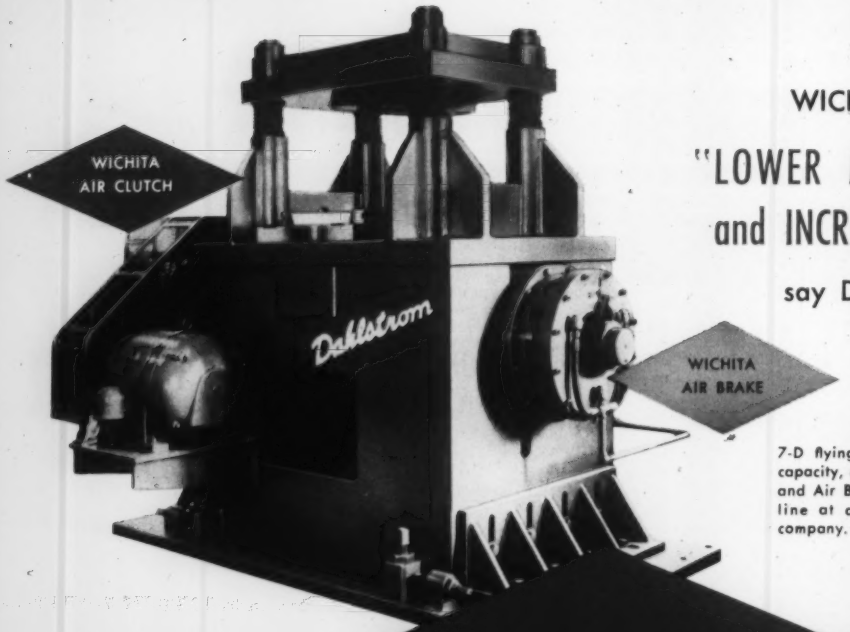
# . . . and now *Duralar** joins this famous family of fine pencils

*The only pencil specifically designed for work on matte-surface tracing film of Mylar®, DURALAR is the newest in the complete line of fine MARS drafting products. All are imported from West Germany and made to meet the highest professional standards. Below ● Bright-hued LUMOCHROM pencils in 24 colors for color-coded drafting and perfect reproduction ● LUMOGRAPH graphite drawing pencils in 19 degrees; some degrees available with erasers, some with special chisel points ● TECHNICO lead holders for color and black graphite drawing, with new sure-hold finger grips and degree markings for quick identification; also with clips, for pocket use ● NON-PRINT pencil and leads make notes and sketches that will not reproduce ● Pencil sharpeners in STANDARD and "DRAFTSMAN" models; latter with adjustable point-length feature. ®T.M. FOR duPONT'S POLYESTER FILM

**MARS**

J. S. STAEDTLER, INC.

HACKENSACK NEW JERSEY




WICHITA GIVES US —

# "LOWER MAINTENANCE COST and INCREASED DEPENDABILITY,"

say Dahlstrom customers

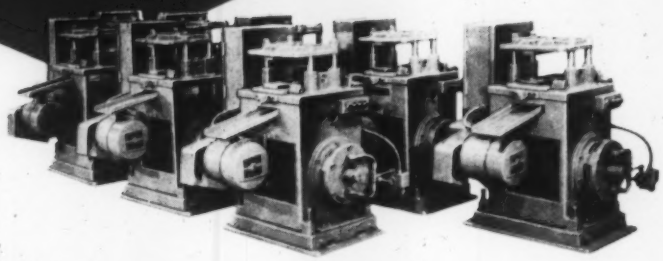
7-D flying die type cut-off press, 80 ton capacity, equipped with Wichita Air Clutch and Air Brake. This unit part of Dahlstrom line at a Pennsylvania steel products company.

## "Better PERFORMANCE on the flying die type cut-off presses with Wichita Air Clutches and Brakes," SAYS DAHLSTROM ENGINEER

The demand is for high-speed efficiency in flying die type cut-off presses and top performing clutches and brakes. That's why Dahlstrom Sales Engineers are highly pleased with the performance story provided by the Wichita Air Clutch.

To quote . . . "Our customers have reported *lower maintenance cost* and *increased dependability* of the equipment. We have also noted, *better performance* since using Wichita Air Clutches and Brakes on our presses, shears and recoiling reels."

Whether on new equipment or conversion of existing equipment insist on top performance. *Specify Wichita Clutches and Brakes.*



3-D flying die type cut-off presses, to be used as cut-off or pre-notched machines, 12-ton capacity, equipped with Wichita Air Clutches and Air Brakes. These 8 units installed at an automotive plant in Ohio.

**Contact your nearest Wichita Engineer!**

Brehm-Lahner, Inc., Detroit, Michigan
L. H. Fremont, Cincinnati, Ohio
W. G. Kerr Company, Pittsburgh, Pa.
Smith-Keser & Co., Avon, Conn., Philadelphia 44, Pa., and New York, N. Y.
Frank W. Yarline Co., Chicago, Illinois
Larry W. McDowell, Long Beach, California
Andrew T. Lobel, Denver, Colorado
Robert P. King Co., Cleveland, Ohio
Norman Williams, Houston, Texas
Allied Transmission Equipment Co., Kansas City 8, Missouri
Donald E. Harman, Dallas, Texas
C. Arthur Weaver, Richmond, Virginia
Malcolm S. Cone, Memphis, Tennessee
Dominion Power Press Equipment, Ltd., Burlington, Ontario, Canada
R. E. Kunz, Seattle 4, Wash.
W. G. Ballantyne Co., Portland 4, Ore.
Bates Sales Co., St. Louis 1, Mo.

**WICHITA Clutch COMPANY, INC.**
WICHITA FALLS, TEXAS, U.S.A.

Circle 426 on Page 19

# THIS IS GLASS

A BULLETIN OF PRACTICAL NEW IDEAS FROM CORNING

## POPPER THAT'S A STOPPER

It has been pointed out to us that every day the world survives, fewer are the chances that anything is the most, the biggest, the only, or the first.

But this corn popper *is a first*—to the best of our knowledge.

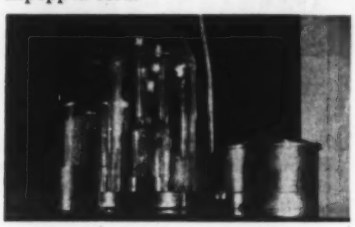
This machine pops corn with *hot* air—and all the action takes place *before your eyes*.

But that's putting the cart before the horse, because it was quite a number of moons ago when the designers at Electri-Cooker Division of General Foods were at the idea-developing stage.

They wanted a *new* way of popping corn. And they wanted to boost sales by having all the popping parts *visible*.

So, they developed a way of turning kernels into a fluffy delight with a *blast* of hot (about 200° F.) air. Then they turned to Corning.

And Corning in turn came up with a number of key components made from a PYREX brand glass. Included are a 17-inch display dome, 13-inch lamp chimney, and an 8-inch chamber for storing unpopped corn.



Why a PYREX brand glass? Because you can use it at elevated temperatures without worrying about thermal shock. (For example, PYREX brand glass No. 7740 has a linear coefficient of expansion of 32.5 x $10^{-7}$ in./in. between 0° and 300° C.)

Also, you can see through glass (an obvious but still extremely useful feature).

And glass is so easy to keep clean, there's no place for dirt to lodge in its *smooth* surface. Glass No. 7740 also is resistant to the attacks of most acids and alkalies and stands up well under distilled water.

You can find machines dispensing corn popped by hot air at Woolworth's, Grant's, Kresge's, McCrory's, Newberry's and Sears Roebuck & Company. You can find *glass* answers to one of your materials or component problems by coming to Corning.

You can get a head start by perusing "This Is Glass," a 64-page, well-illustrated primer. And/or ask for Bulletin B-83, a detailing of mechanical, thermal, electrical, and chemical properties for three of Corning's most popular types of glass. Use the coupon.

## PURITY—KEY TO FUSED SILICA'S VERSATILITY

What material would you pick if you had the problem of accurate spectrum *transmission*, growing *high-purity* crystals, or building a component that would *not* darken under radiation?

The answer: Corning's 100% Fused Silica, an extremely versatile material that will handle these, as well as many other, specialized tasks. And the key to this material's versatility is its *extreme* purity.

Capacity to stand up to high temperatures, coupled with optical properties that yield excellent schlieren or shadowgraph quality, makes fused silica a natural for installation in wind tunnels for designing supersonic aircraft and missiles.

**Optical purity and a high softening point (1585°C.) make Corning's 100% Fused Silica useful in wind tunnel windows.**

Fused Silica also is used in ultrasonic delay lines, being well suited for handling delays ranging from 10 to 16,000 microseconds. More: You'll find this material possessed of high electrical breakdown resistance, low dielectric loss, and low expansion. And it is permeable to helium.

Uses (other than ultrasonic delay lines and windows for wind tunnels) include the following: windows for high-temperature applications, windows for hot cells, and the optical components for ultraviolet instruments.

All the facts are now available in spec sheet form. Check the coupon.

## NEW—CELLULAR CERAMICS

Now, for the first time, from Corning's Cercor process, you can get thin-walled cellular ceramics.

These cellular ceramics are lightweight, resist oxidation, and have an extremely high surface area. Here is a sampling of Cercor products.

The material used to make these objects has 1500 square feet of surface area per cubic foot. Individual wall thickness averages only 0.005 inch; weight is only 30 pounds per cubic foot.

This material can withstand temperatures up to 1800° F. with virtually no thermal expansion, and can be operated continuously at 1290° F. At either temperature you don't have to worry about thermal shock or oxidation.

To provide additional strength, a ceramic coating can be bonded to the exterior of most cellular forms.

The composition of the Cercor materials may be changed to provide desired physical and chemical properties, and further development is expected to result in a broadening of potential configurations and product shapes.

Suggested uses so far include structures for use in gaseous heat exchangers, catalyst supports, burner plates, column packing, and acoustical filtering, flow control, insulation, and structural materials in high-temperature applications.

Inquiries invited. And/or ask for a just published bulletin detailing all pertinent data and characteristics.

CORNING MEANS RESEARCH IN GLASS

**CORNING GLASS WORKS** 52 Crystal Street, Corning, N.Y.

Please send me: ☐ "This Is Glass"; ☐ Bulletin B-83; ☐ Fused Silica; ☐ CERCOR

Name_____ Title_____

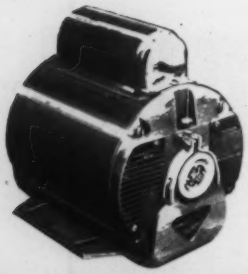
Company_____

Street_____

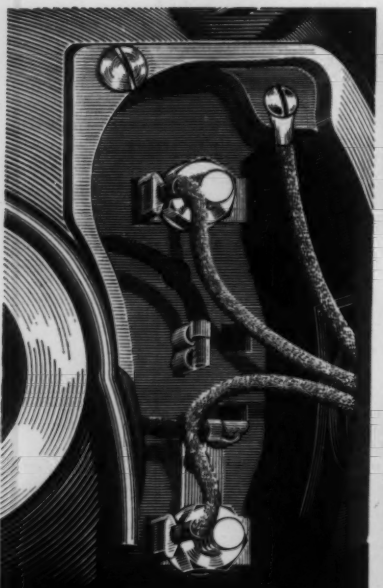
City_____ Zone____ State_____



Circle 427 on Page 19



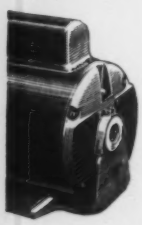
# 6 Reasons why REDUCE



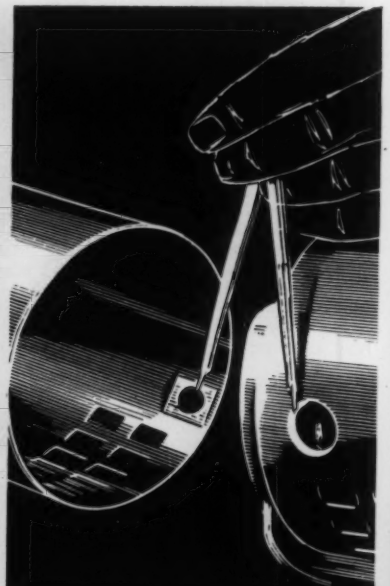
## EASY TO HOOK UP

**This enlarged wiring compartment saves hook-up time on the assembly line**

Wiring compartments on G-E motors are now roomier and easier to work with. An enlarged opening allows greater accessibility. A narrower terminal board makes it easy to bring in leads from conduit. There are no extra studs on the board to result in "hook-up confusion." Easier, more accurate wiring results. How much can this extra value save you?



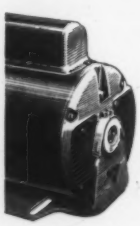
GENERAL ELECTRIC



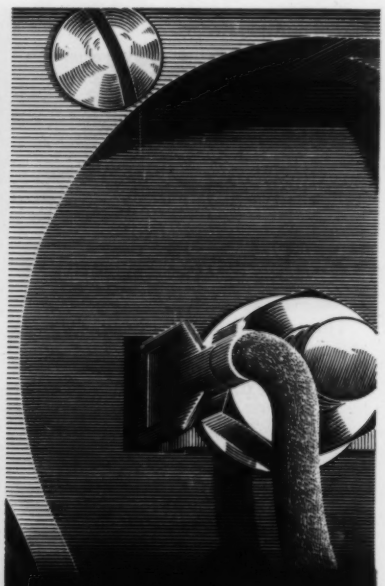
## FAST CONDUIT CONNECTION

**Special speed nut permits conduit connection from outside; cuts connection time 50%**

Conduit connection is greatly simplified by single-thread speed nut welded inside the motor shell. This feature permits connection of conduit from outside the motor in half the time normally required with conventional lock nut. No waste of time fumbling with a loose nut, no possibility of dropping it in the motor or on the floor. It's a real time saver!



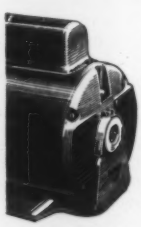
GENERAL ELECTRIC



## FAST LEAD CONNECTION

**Now plug-in connectors on all terminals cut wiring time in half**

For the first time on all single-phase Form G motors, General Electric offers time-saving quick connectors on *all* external and internal contacts.* Wiring time is cut in half. (Studs have been retained for conventional wiring.) Simply plug in the leads. Fast, positive connections are assured. Try it yourself. You'll like this new General Electric extra value.



* Explosion-proof and a few special motors excepted.

GENERAL ELECTRIC

**JUST ASK YOUR GENERAL ELECTRIC SALES ENGINEER**

General Electric Form G motors . . .

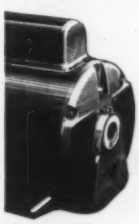
# ASSEMBLY TIME

LUBRICATION
AFTER 1 YRS NORMAL OR 1 YR HEAVY DUTY SERVICE ADD OIL ANNUALLY NO REOILING REQUIRED ON LIGHT DUTY APPLICATIONS WITH TOTAL OPERATING TIME UNDER 25,000 HRS. USE ELECTRIC MOTOR OR SAE 10 OIL
DO NOT OVER OIL
TO DISASSEMBLE MOTOR REMOVE BEARING END CAP ON TERMINAL END THEN REMOVE SHAFT CLIP BY RELEASING TAB
GENERAL ELECTRIC
AC MOTOR
MOD 5KH36KG278T
RPM 1725
PH 1
55C
CODE M
60
CONT
TP

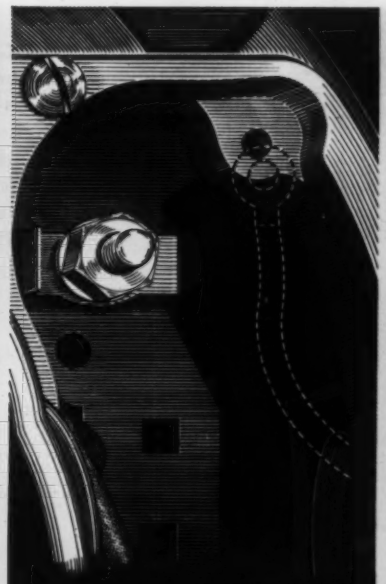
## EASY-TO-READ NAMEPLATES

**New permanent instructions and data simplify installation and servicing**

Operating data on Form G motors is both legible and permanent to help you select, install and service without guesswork. The nameplate is engraved, then paint-filled for extra readability. Oiling instructions are lithographed on the terminal box cover plate. Lets your customers know exactly how *little* maintenance is required. *See* this extra value!



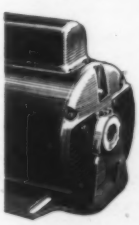
GENERAL ELECTRIC



## SAFE, SIMPLE GROUND

**Built-in grounding lug permits fast, easy grounding to meet UL standards**

Now on Form G motors you get a built-in grounding lug that meets UL standards for grounded third lead when required. With a self-forming screw you can make ground connections quickly, easily and inexpensively. This feature assures safe, permanent grounds. There's no chance of disconnection during maintenance. Ask for details about this extra value.



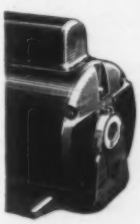
GENERAL ELECTRIC

## COMPACT, LIGHTWEIGHT

**Small, light Form Gs easy to assemble; cut handling and shipping costs**

Up to 50 per cent lighter, 40 per cent smaller than old-style designs, General Electric's Form Gs are easier to handle, faster to install. Compact motor requires less mounting space and material; cuts down "assembly-line fatigue" caused by heavier motors; reduces stock space and shipping costs. You can't help but *save* with compact, lightweight Form Gs!

702-90



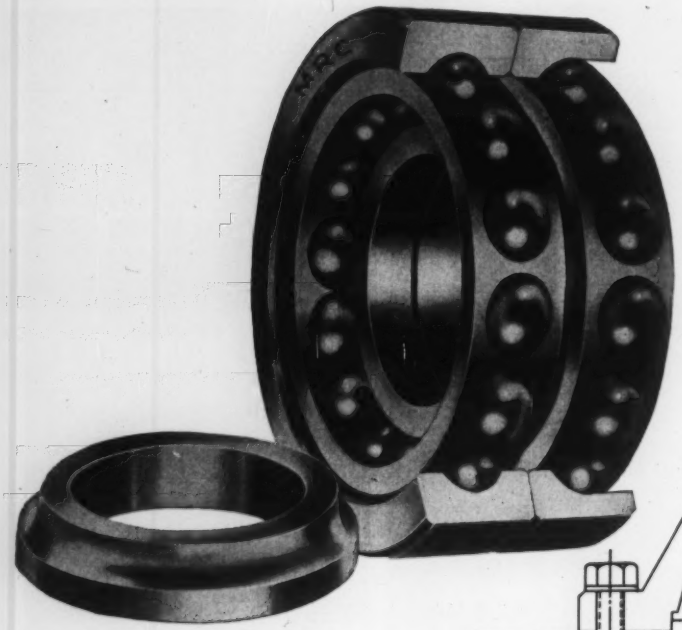
GENERAL ELECTRIC

## ABOUT THE NEW FORM G "EXTRA VALUE" FEATURES

# MRC 7000-D and 9000-UD

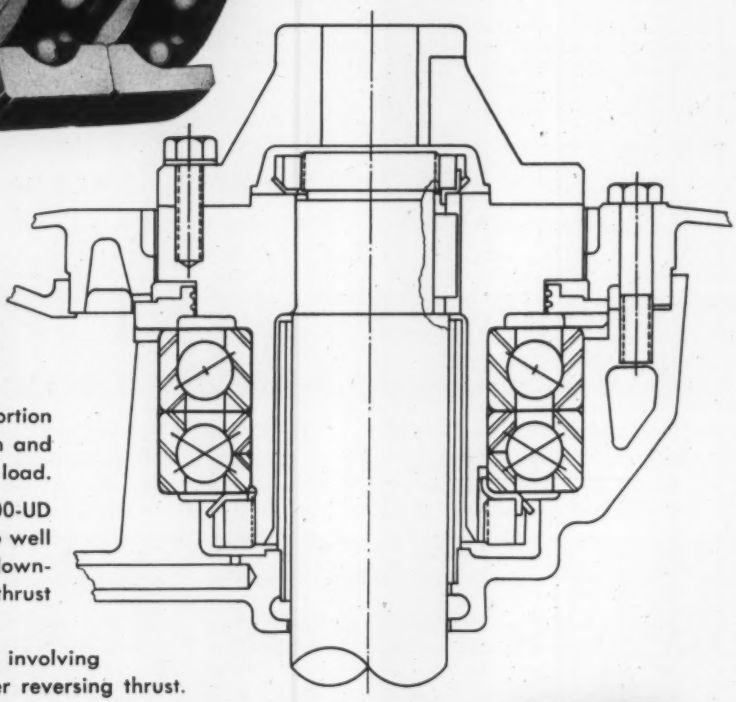
## Ball Bearing Combinations

*provide DOUBLE the thrust capacity available with regular Duplex bearings*



**M-R-C 7000-D single-row angular contact bearings and M-R-C 9000-UD single-row two-directional thrust bearings can be used in combination mountings to provide approximately double thrust capacity in one direction and single bearing thrust capacity in the opposite direction.**

**This combination mounting, requiring twice single-row width, results in almost 100% gain in thrust capacity in one direction, with no change in the other direction.**



More than one 7000-D bearing may be used in conjunction with a 9000-UD bearing to provide still greater thrust capacity in one direction when required. The 9000-D single-row bearing performs the dual function of carrying its proportion of the heavy thrust load in one direction and supporting all of the reversing thrust load.

This combination of 7000-D and 9000-UD bearings was originally selected for deep well pump applications, supporting heavy downward thrust load as well as reversing thrust due to upsurge.

It is suitable for use in any application involving heavy thrust in one direction with lighter reversing thrust.

*Write OUR Engineering Department regarding YOUR bearing problems*

**MARLIN-ROCKWELL CORPORATION**

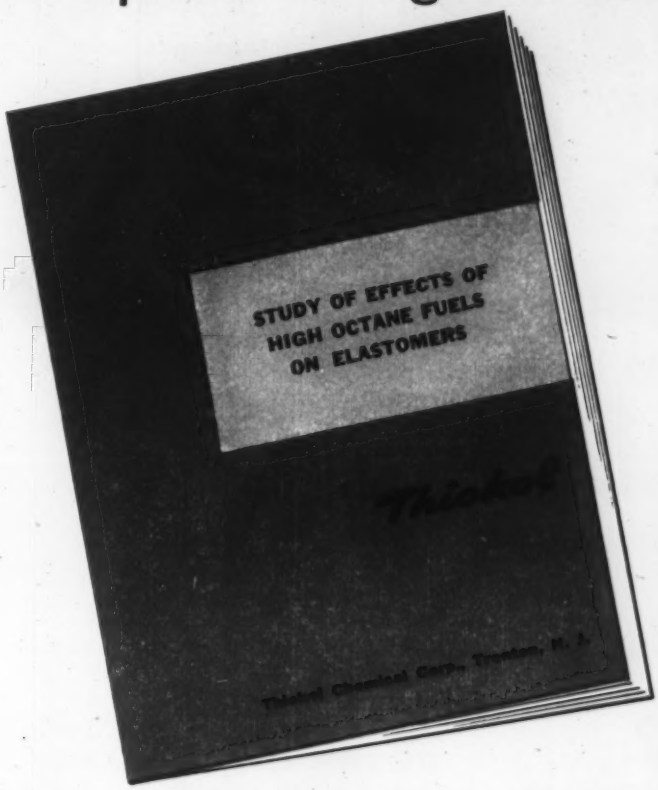
Executive Offices: **Jamestown, N.Y.**

MRC BALL AND ROLLER *bearings*



Circle 431 on Page 19

# Research Underscores Need of New Approach to Manufacture of Hose and Other Rubber Equipment Exposed to High Octane Gasoline




*Laboratory study shows dangerous degradation of present elastomers under new aromatic fuels*

The trend to higher octane gasolines dictates a re-evaluation of rubber requirements – in the petroleum field – at refinery, transportation and service station levels. Exhaustive tests by THIOKOL point up the need.

Six different types of synthetic rubber now widely used – including THIOKOL ST and FA polysulfide crudes – were used for the tests. Immersed in fuels of varying aromatic content, from 25% to 100%, the elastomers were measured for volume swell, tensile strength, and low temperature properties. Most synthetics showed a marked reduction in physical properties and serviceability, while the THIOKOL crudes satisfactorily resisted "high octane rot."

The detailed results of this THIOKOL study hold great significance for suppliers in the rubber industry. Coupon will bring you a copy of the complete report.

**FOR MORE INFORMATION:**
**Mail coupon to Dept. 44, Thiokol Chemical Corp., 780 N. Clinton Ave., Trenton, N. J. In Canada: Naugatuck Chemicals Division, Dominion Rubber Co., Elmira, Ontario.**

Gentlemen: Please send me a complete report of your aromatic fuel study.

Firm_____

Street_____

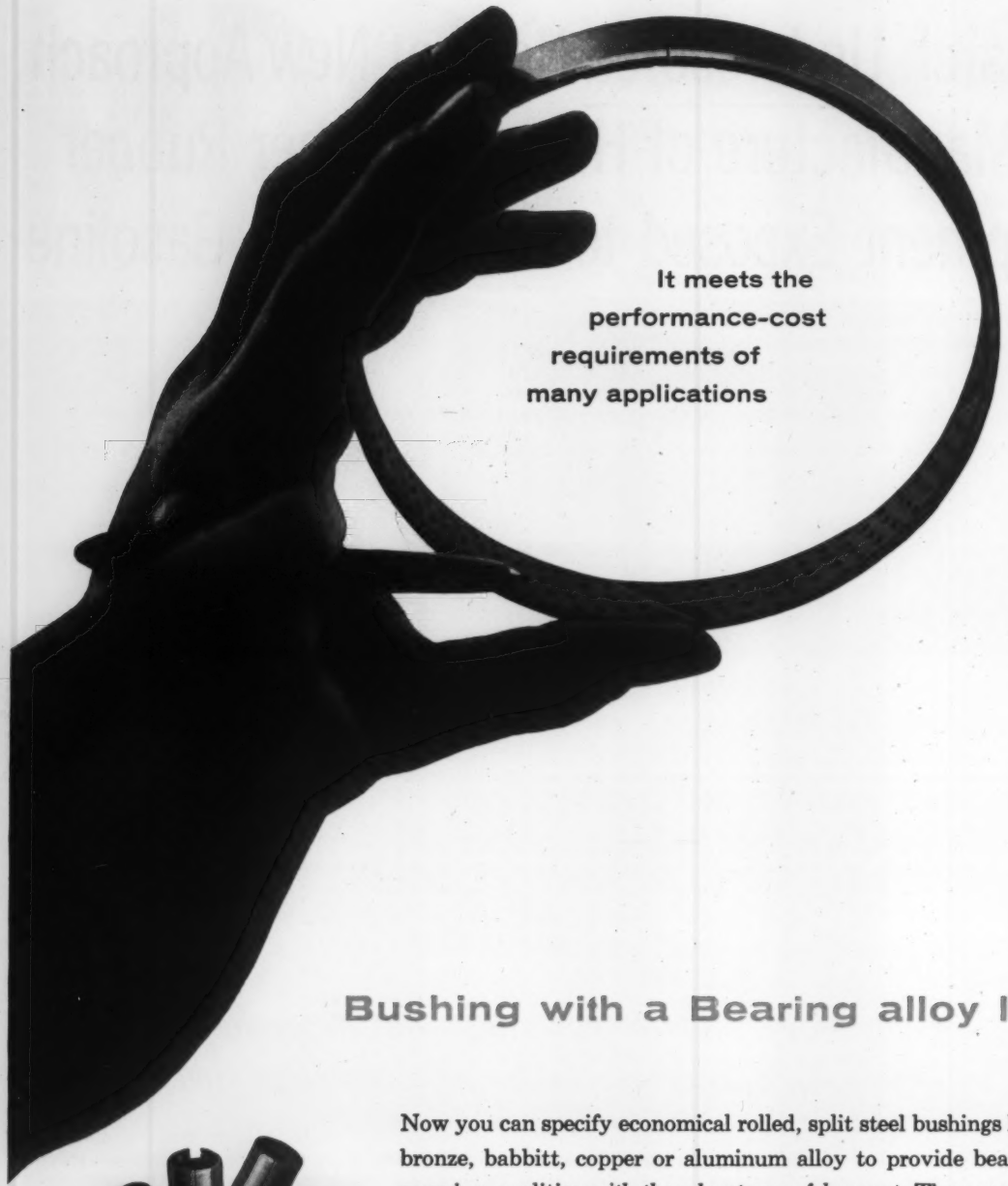
City_____ State_____

Your Name_____

**Thiokol®**
**CHEMICAL CORPORATION**

*Registered trademark of Thiokol Chemical Corp. for its liquid polymers, synthetic rubbers, rocket propellants, plasticizers and other chemical products.


Circle 432 on Page 19




## Bushing with a Bearing alloy lining

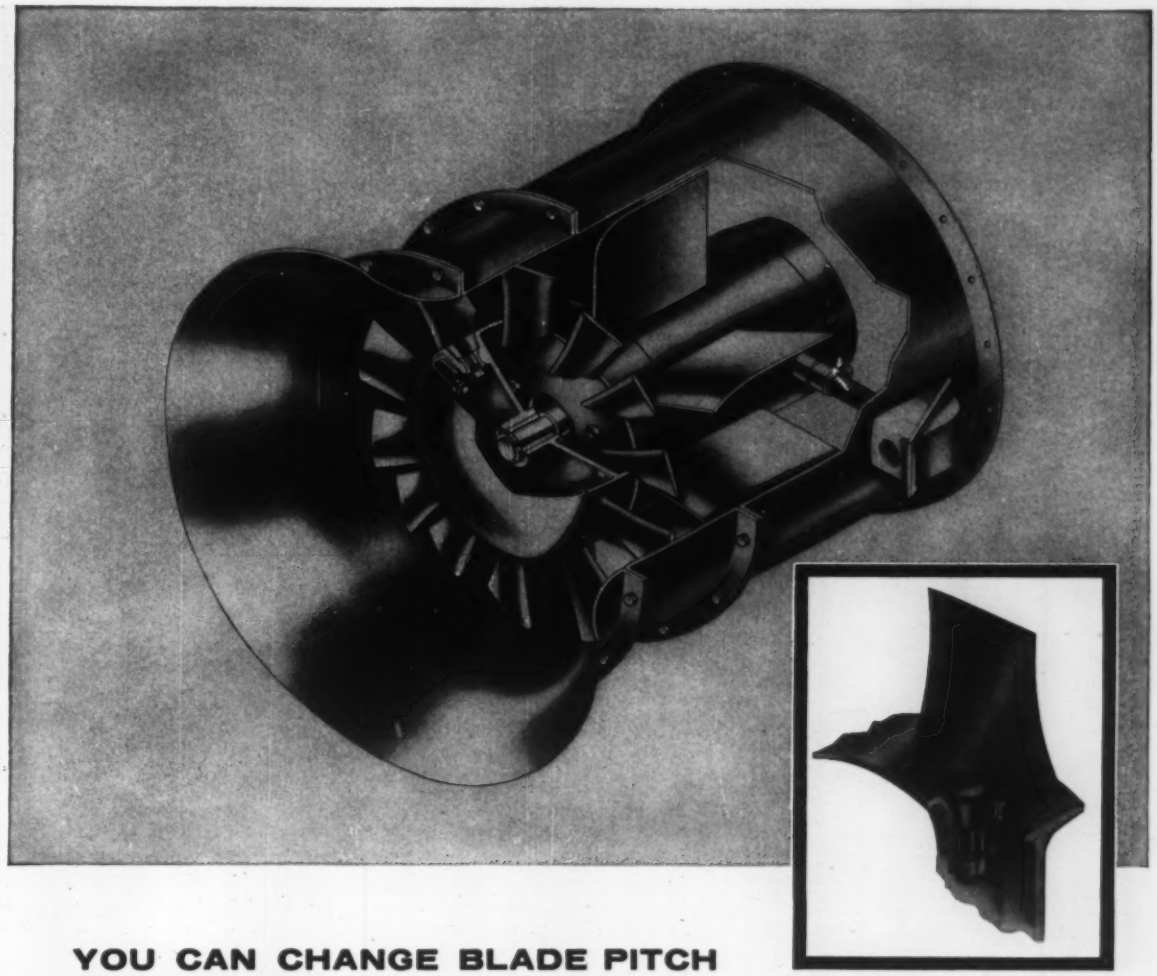
Now you can specify economical rolled, split steel bushings lined with bronze, babbitt, copper or aluminum alloy to provide bearing load-carrying qualities *with the advantages of low cost.* They are available in many lengths and diameters, with straight, clinch, butt or special seams. They can be ball indented and have oil holes, grooves, notches, slots, as required. Quality controlled manufacturing to meet your specifications. We provide complete engineering service. A copy of the "Formed Bushing Design Guide" will be sent on request.

# FEDERAL-MOGUL DIVISION

FEDERAL-MOGUL-BOWER BEARINGS, INC., 11045 SHOEMAKER, DETROIT 13, MICHIGAN



Circle 433 on Page 19



## YOU CAN CHANGE BLADE PITCH TO CHANGE VOLUME AND PRESSURE WITH

# JOY AXIVANE FANS

If calculated and operational requirements differ . . . if system characteristics change . . . or if resistance is difficult to predict —Joy fans can solve your problem. The blade pitch is adjustable. The factory blade-setting can be changed quickly to provide either a wide pressure-range for any particular volume or a change in volume. The inset photograph shows how this can be done using only a common wrench.

Other advantages: The motor is inside the fan . . . no drive losses. This makes the fan unusually compact and efficient . . . easy to mount. There are *1600 standard models* in all combinations of horsepower, pressures, and volumes. Also available with V-belt drives. Send in the coupon now for complete information.

**Joy Manufacturing Company, Oliver Building, Pittsburgh, Pa.** In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario.

WSW-17317-287

**JOY SAVES YOU MONEY ON AIR**

**Joy Manufacturing Company**
Axivane Fan Engineering, Dept. 648
Oliver Building, Pittsburgh 22, Pa.

name and title

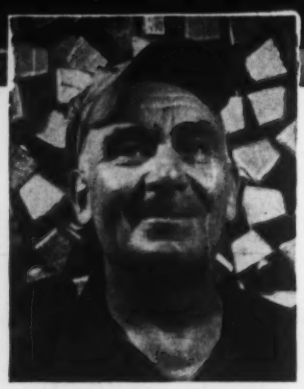
company

street address city zone state

I am interested in Joy Axivane Fan information on:

# accurate!

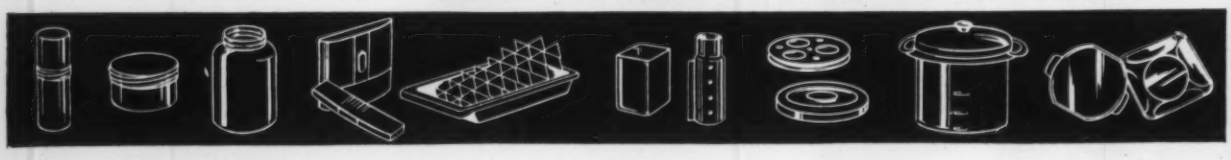
...in gauge *and* temper!

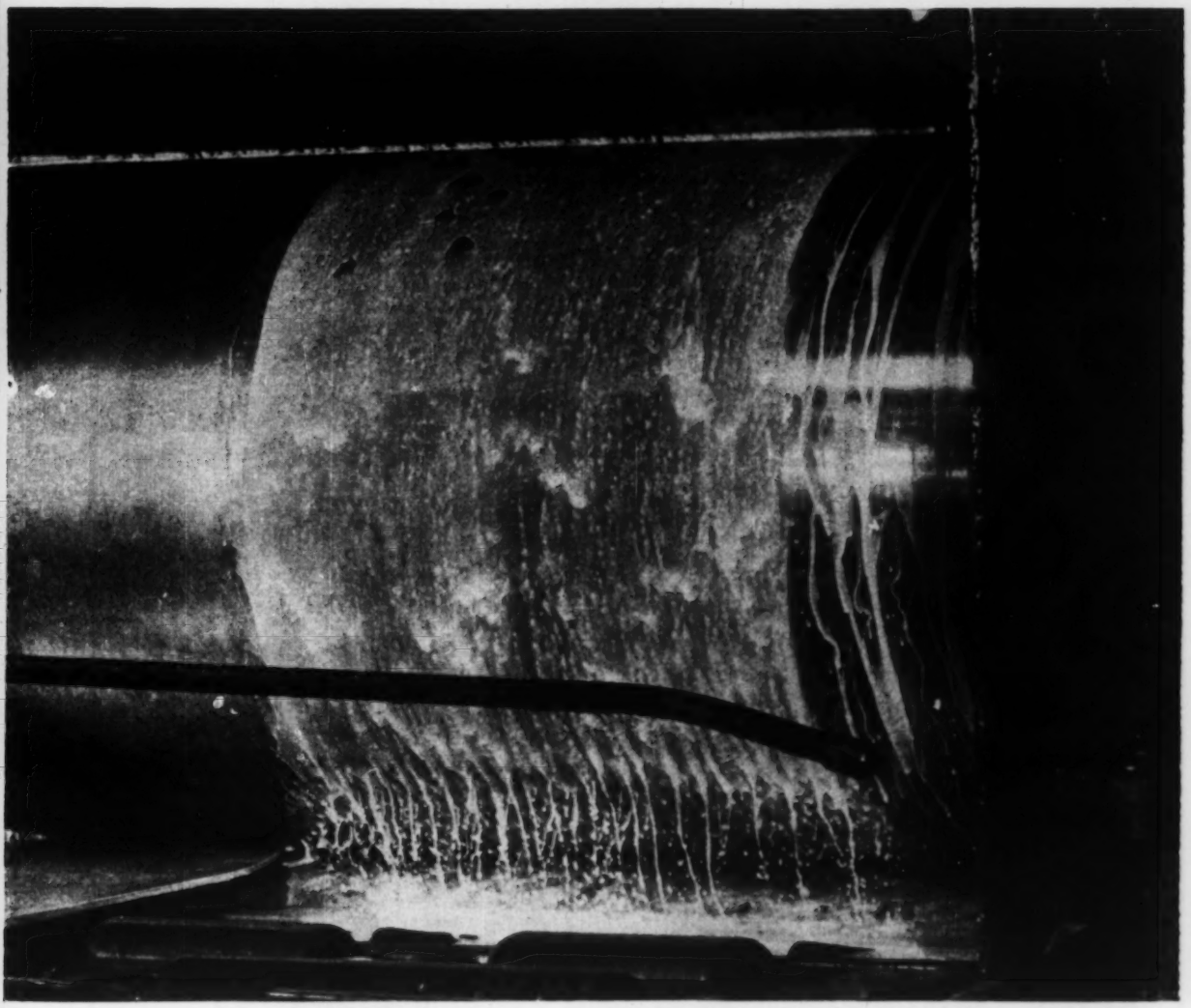


John Broehm, big boss of the breakdown rolls, has been putting pressure on aluminum for 31 years. "No matter how thick or thin you squeeze it, it's always 'the finest aluminum,'" is the way John puts it.

## The pressure's

Much of the sheet aluminum used in our five large fabricating plants is produced in our *own* rolling mill. This on-the-spot control permits us to give our customers finished components made from metal of standard or special tempers and thicknesses. Aluminum sheet for parts of all sizes, from the smallest, light-gauge tube shields for portable radios to heavy-gauge deepwell cookers and 4-foot ceiling panels, is accurately controlled throughout the breakdown roll and rolling mill processes. This control of accuracy assures a minimum



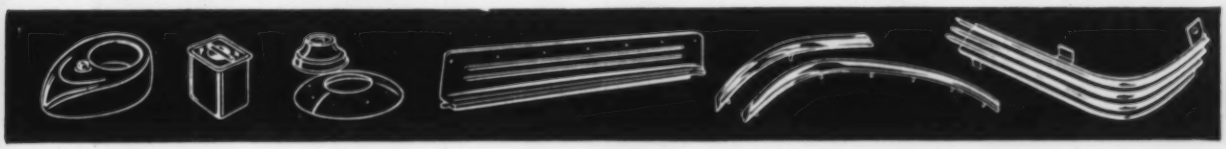


# on...375 tons of it!

rejection rate of the end product into which the metal is formed. Our rolling mill operation, with its entire output for exclusive use in our stamping plants, has the further advantage of speeding up production schedules, since it eliminates delays due to shipment of metal from outside sources.

If accurate operation and skilled production planning appeal to you, send us your inquiries . . . or even better, visit our plants to see how our facilities can help *you*.

**MIRRO ALUMINUM COMPANY**
**(Formerly Aluminum Goods Manufacturing Company)**
MANITOWOC, WISCONSIN
FIFTH AVENUE BLDG., NEW YORK 10 • MERCHANDISE MART, CHICAGO 54

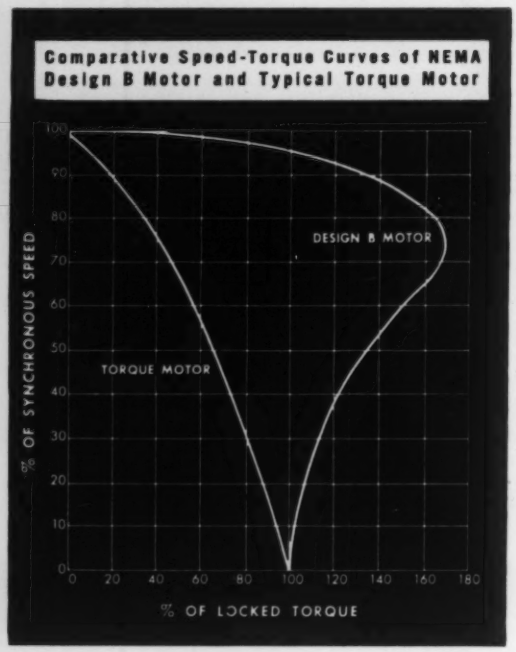


# SELECTING TORQUE MOTORS

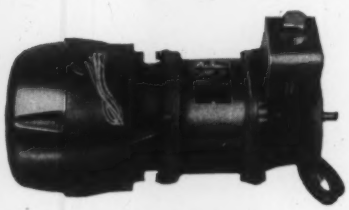
The torque motor, unlike any other electric motor, is a special from the word go. That situation alone makes Peerless one of the best sources for torque motors in ratings from 2 oz. in. to 200 lb. ft.

Torque motors deliver maximum rated torque without damage to the windings when stalled across the line at full voltage for predetermined periods. Peerless also builds torque motors which provide a nearly constant torque while operating at less than synchronous speeds.

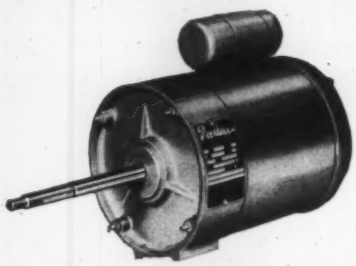
All standard frame sizes; all types of mountings; high torques; special paint and varnish treatments; and Class A, B and H insulation are available from Peerless. Torque motors require unusually close cooperation between the motor supplier and the customer's engineers. This cooperation is a Peerless specialty. We will work with you to produce the one torque motor that powers your product best.



Weather-Tight Special Flange



Explosion-Proof Torque Motor with Brake



Special Flange Reversing Hoist Motor Single Phase

The speed-torque curve varies from that of a conventional motor. The torque motor curve is almost linear. Maximum torque occurs at the stalled position. For this reason, torque motors are used most often where a holding or resisting force is required.

*NEW TORQUE BULLETIN-This bulletin outlines basic facts about Peerless torque motors and shows applications. It is available FREE. Write for it today.*

ELECTRIC MOTOR DIVISION

THE Peerless Electric® COMPANY

FANS · BLOWERS · MOTORS

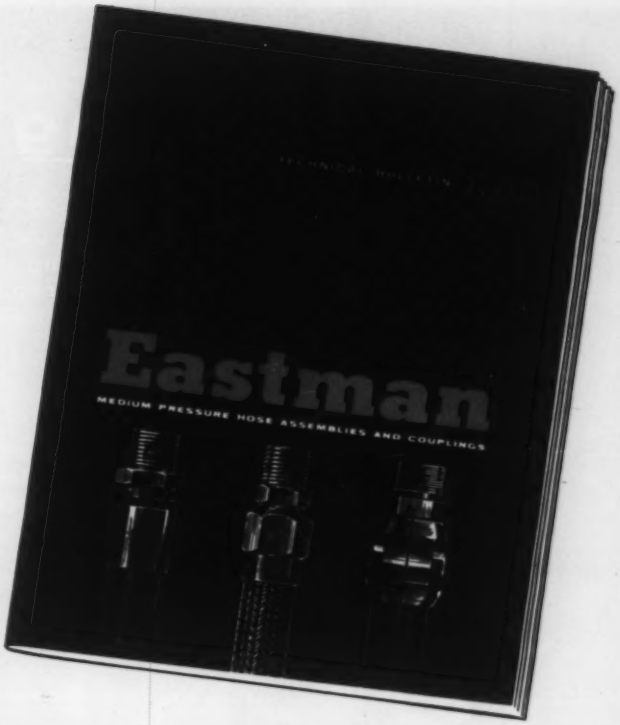
1520 W. MARKET ST. · WARREN, OHIO



Circle 436 on Page 19

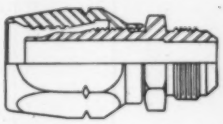
# another NEW BOOK with that Eastman LOOK

**36 pages on medium to low pressure hydraulic hose and tube assemblies**



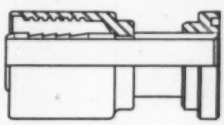

**REUSABLE COUPLINGS FOR RUBBER COVER HOSE**

Exclusive Eastman design directs flow of hose into machined recesses of insert and coupling body. Doubles the hold, assuring longer service. Pages 26 & 27.



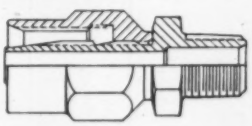
**PERMANENTLY ATTACHED FLANGE HEAD COUPLINGS**

Attractive, low cost permanent hose attachment—plus convenience of split-flange head couplings with 0 to 90° stems permitting full 360° positioning. Pages 20 & 21.



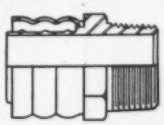
**REUSABLE COUPLINGS FOR COTTON COVER HOSE**

Eastman engineered two-piece coupling can be assembled without stripping hose. (Can also be used on thin rubber cover hose without removing cover.) Full details on pages 24 & 25.



**PERMANENTLY ATTACHED COUPLINGS FOR SUCTION HOSE**

For use on spiral wire return lines. Maximum orifice permits rapid return of hydraulic fluid assuring adequate supply from lever to load for top payload power. See page 31.



**Eastman** *first in the field*

**SAFEGUARDING AMERICA'S LIFELINES OF MOBILE POWER**

## ARRANGED FOR YOUR CONVENIENCE TO MAKE IT EASIER FOR YOU TO:

**Locate your required assemblies**
**Determine the proper couplings**
**Specify according to pressure**

EASTMAN'S New Technical Bulletins on Hydraulic Hose and Tube Assemblies are the talk of the trade!

Here's the second in the series which you will want to send for right away—Technical Bulletin No. 100 on Medium to Low Pressure Assemblies. Working Pressures range from 3000 psi to 75 psi (for return suction lines).

Easy-to-use tables arranged opposite dimensional drawings for the entire Eastman line of Couplings: Permanently Attached, Clamp Type, Flange Type and Reusable—for One Wire Braid Rubber Cover, Cotton Cover and Suction Hose—plus necessary adapters and tube fittings.

This is a necessary companion to the first in Eastman's New Series of Bulletins—No. 200, on High Pressure Assemblies. Be sure that your personnel is supplied with copies of *each* of these modern bulletins.

*Write today! Send the quick service coupon below.*

**EASTMAN MFG. CO., DEPT. MD-1, MANITOWOC, WISCONSIN**

Please send me.....copies of Bulletin 100 on Medium to Low Pressure Eastman Assemblies for 1-wire braid hose.

Please send me.....copies of Bulletin 200 on High Pressure Eastman Assemblies for 2-wire braid hose.

Also.....copies of Bulletin 500 on Adapters and Adapter Unions.

Name _____ Title _____

Company _____

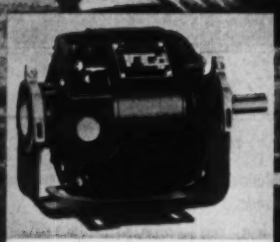
Address _____

# Here Timing Counts . . .

The pitch is on the way; from here on in, the batter's timing really counts! And when it's *your* turn at bat to solve a motor-drive problem for appliances or equipment, Emerson-Electric will work with you to make your timing *perfect!*

Remember . . .

- Emerson-Electric produces *custom-engineered* motors to suit *your specific needs.*
- We specialize in solving motor-drive problems *like yours,* and we have a back-log of more than 65 years of experience.



**To get the kind of timing that pays off in the profit column, call, wire or write Dept. M-352 today. The Emerson Electric Mfg. Co., St. Louis 21, Mo.**

**EMERSON-ELECTRIC** *of St. Louis · Since 1890*

# Technical data for gasket design and selection

NUMBER NINE

## How to get better sealing at no extra cost in fiber sheet gasket applications

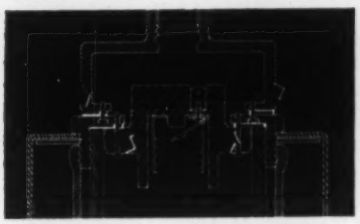
Economy is among the most important design objectives, whether it be an opportunity to reduce costs or a way to improve performance at no increase in price.

A new beater-saturated gasket material—Accopac N-852—is delivering such economy in a variety of applications where conventional plant fiber gaskets have been used.

In every case, N-852 was used at no increase in cost, and in many instances, this new material delivered a substantial bonus in better performance.

Accopac N-852 is made by a process pioneered and patented by Armstrong. In this process, cellulose fibers are combined with a synthetic latex binder and formed into dense, homogeneous sheets of unusual uniformity.

The binder in N-852 cannot be volatilized or extracted in any recommended application. As a result, gaskets cut from this new material will not shrink in use or in storage.



The efficiency of this vapor-tight light fixture was reduced when binder in a conventional plant fiber gasket volatilized and condensed inside globe. The non-extractable binder in N-852 helps eliminate problems of this type.

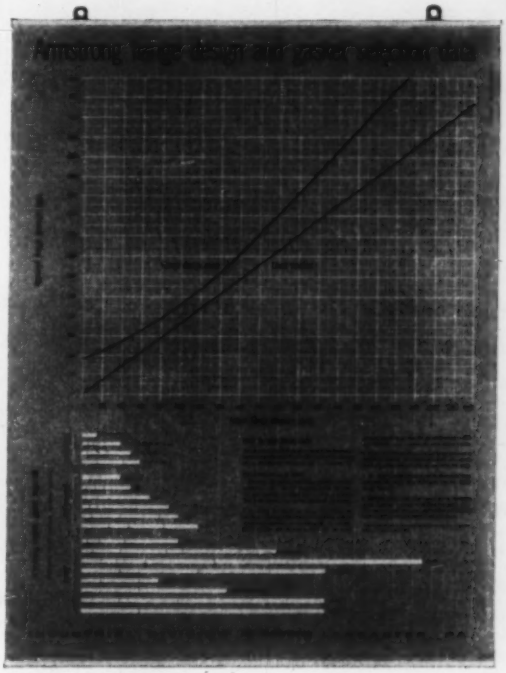
Accopac N-852 is recommended for any sealing job where glue-glycerine saturated materials are now being used. Typical applications are in caps for gasoline tanks and radiators, master cylinders for brakes, gear case covers, and hand hole covers.

N-852 is available in sheets, rolls, or die-cut parts. It can be obtained direct from Armstrong or locally through Armstrong Approved Gasket Fabricators throughout the country. Write to us for more information on Accopac N-852—or a list of Armstrong Approved Fabricators.

## Free wall chart helps assure positive seals and guides in proper gasket selection

Leaks in gasketed joints are at times attributed to such things as compression set or torque loss, when the real problem is simply that the flange load is too low to maintain a seal.

To be sure of adequate unit loads, two things must be considered. The first is the *"seal point"* of the particular gasket material, i.e., the unit pressure required to form a seal. This point is frequently underestimated. It varies widely, even among materials of the same general class.



This 18" x 23" wall chart simplifies flange load calculations and guides in selection of proper gasket material.

The second thing is the *actual* unit load on the gasket, as contrasted with the *apparent* load arrived at mathematically by converting bolt torque to bolt load.

The apparent load and the actual load rarely coincide, because friction on bolt threads results in wide variations in bolt efficiency. Such friction soaks up bolt torque, often to the extent that actual pressure is only a small fraction of pressure anticipated on the basis of bolt torque calculations.

These possible variations in bolt efficiency point up the need for a method of estimating what percentage of the indicated torque load is dissipated in overcoming varying degrees of thread friction.

Research engineers at Armstrong have established by original laboratory procedures the seal points of Armstrong resilient gasket material. In addition, they have developed a simple method of converting apparent flange pressures to actual flange pressures, taking into account a wide range of bolt thread conditions.

This data takes much of the guesswork out of flange load calculations and gasket selection. It gives a designer reasonable certainty of getting loads that will equal or exceed the minimum required for sealing with the various Armstrong materials.

The new method is discussed in detail in the Armstrong Gasket Design Manual, and its major points are consolidated for easy reference on an 18" x 23" wall chart. Copies of the manual and chart are offered at no charge. Please request them on your business letterhead only, addressing your inquiry to Armstrong Cork Company, Industrial Division, 7101 Dean Street, Lancaster, Pennsylvania.

**Armstrong GASKET MATERIALS**

*. . . used wherever performance counts*



Circle 439 on Page 19

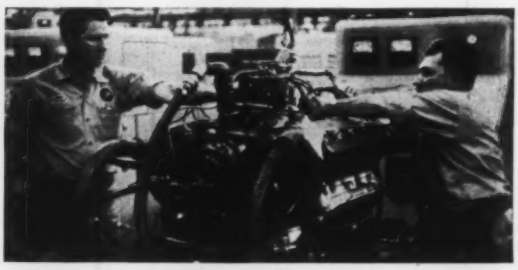
# What the new expansion program of Chrysler M&I Engine Division means to manufacturers of self-powered equipment

*A joint message from Arthur S. Hudson (left), President and Lawrence E. Nelson, Vice President—Sales, Marine and Industrial Engine Division, Chrysler Corporation*

Our division has recently undertaken the most far-reaching expansion of facilities, service and personnel in the history of our business. Much has already been done, more will soon be completed.

Details of all phases of this expansion have been outlined in a brochure, "The Forward Look in Industrial Power," which we will be pleased to send you if you will address a request to us on your executive letterhead.

But even more important perhaps than the details of our expansion is what this expansion means to you, our customers — the manufacturers of self-powered equipment. Let's look at each phase of this expansion in terms of how it will help *your* business!

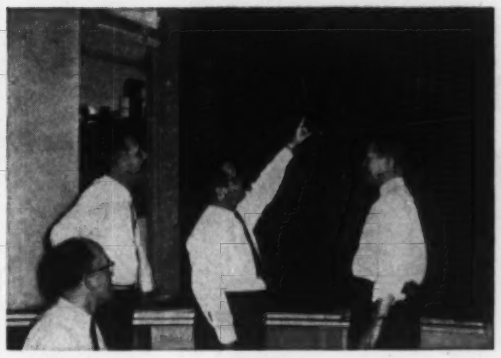


**CUSTOM ENGINE BUILDING FOR INDIVIDUAL APPLICATIONS, INCORPORATING SAVINGS OF AUTOMATED PRODUCTION.**

Production of Chrysler Industrial Engines has been completely re-organized. Basic engine blocks are machined in the huge Chrysler automated engine plants. Production facilities of the division itself are devoted exclusively to building the finished engine as specified — with any of the thousands of possible combinations of options and accessories. This gives you the advantage of an engine built for your individual application at a price which incorporates automated production savings.

*Chrysler-powered equipment for every major industry*

| | | | | | |
|---|---|---|---|---|---|
| Air Compressors | Ditching Machines | Standby Generators | Lift Trucks | Petroleum Pumps | Shovels |
| Aircraft Towing Tractors | Drilling Equipment | Hydraulic Cranes | Loading Machines | Pulp Machinery | Snow Mobiles |
| Arc Welders | Fire Pumps | Industrial Hoists | Mobile Cranes | Road Pavers | Street Sweepers |
| Concrete Mixers | Farm Combines | Industrial Tractors | Motor Coaches | Road Rollers | Winches |
| Construction Pumps | Farm Tractors | Irrigation Pumps | Orchard Sprayers | Scoop Tractors | Yard Cranes |



**FASTER PRICING AND DELIVERY WITH LESS LEAD TIME REQUIRED ON ORDERS.**

Production and production control is now coordinated under one roof. Production scheduling and follow-up procedures assure you that your orders will be produced to exact specifications and delivered on schedule with a minimum of lead time required. There is not only daily, but hourly, contact between all our departments. Where required, "personalized" follow-through on individual orders is possible and practical.

The building of prototypes for testing in new applications has also been greatly accelerated.

**FASTER FIELD SERVICE AND PARTS AVAILABILITY THROUGH NEW ENGINE CENTERS, EXPANDED DEALER NETWORK.**

New Chrysler Industrial Engine Centers are now being established at strategic service points throughout the United States. Together with an expanded dealer network, they will offer even the most remote users of your Chrysler-powered equipment efficient, 24-hour service, plus immediate delivery of replacement parts and engines.

Each engine center has a large and complete inventory of industrial parts and replacement engines available on regular and 24-hour emergency basis, delivered by special service trucks. In addition, each engine center has ample service buildings, tools and trained engine specialists to provide service for all types of Chrysler-powered equipment in the area.

Our factory service force has also been expanded in both regional and district offices to provide fast, on-the-job help for you and users of your Chrysler-powered equipment.

**CONTINUOUS IMPROVEMENT OF ENGINE PERFORMANCE AND DEPENDABILITY THROUGH EXPANDED PRODUCT DEVELOPMENT AND RESEARCH PROGRAM.**

Better and still better power for your particular application is the goal of our expanded research, development and field-testing program. The more economy, dependability, trouble-free performance we can build into Chrysler Industrial Engines, the more desirable your products are to your customers. In addition to improving present applications, we are particularly eager to work with manufacturers on pilot models to expand the range of Chrysler-powered applications, for we know the success of our product depends upon how well it works for you.

We hope that you will call or write to us about your power requirements. One of our sales engineers will bring you a new Chrysler Product Line Catalog and help you *select* and *price* the exact combination of engine, accessories and equipment to fit your specific application — *right at your desk.*

CHRYSLER

MARINE AND INDUSTRIAL ENGINE DIVISION
CHRYSLER CORPORATION • DETROIT 31, MICHIGAN

Marine & Industrial Engine Division
Chrysler Corporation, Detroit 31, Michigan

☐ Please send me a copy of your new brochure, "The Forward Look in Industrial Power."

☐ Please have a sales engineer bring me a copy of your new Product Line Catalog.

NAME_____ TITLE_____

COMPANY_____ PRODUCT_____

ADDRESS_____ CITY_____ STATE_____

***Another new development using***

# B.F.Goodrich Chemical *raw materials*

*"Therminate" windows are made with Geon rigid vinyl by Woodlin Metal Products Company, Marshall, Michigan, in standard sizes, in picture window and sliding window sizes and with jalousies. B.F.Goodrich Chemical Company supplies the Geon rigid vinyl material only.*

## FRAME AND SASH ARE MADE OF GEON—

*no more condensation problems*

Frost and condensation problems have been licked with this new window made with Geon rigid vinyl material. There is no moisture precipitation, even under conditions of 18°F. outside, 74°F. inside, with relative humidity as high as 60% .

The frame is predominantly of Geon rigid vinyl with aluminum trim sections; sash is completely of Geon. There is no pitting, rusting, corroding or warping. The window unit can be manufactured in colors, or painted to match house trim.

There is no metal-to-metal contact in the specially designed seal. No pile or metal weatherstripping is required. Yet these windows can withstand water infiltration tests with pressures equal to 45 mph winds.

Geon is the remarkable plastic material available in many forms to become the key to a new or improved product. For information, write Dept. LO-1, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

**B.F.Goodrich Chemical Company**
**a division of The B.F.Goodrich Company**

**B.F.Goodrich**

**GEON polyvinyl materials • HYCAR rubber and latex**
**GOOD-RITE chemicals and plasticizers • HARMON colors**



Circle 441 on Page 19

Circle 442 on Page 19→

# A-B Reliable Control Units

## for every industrial application

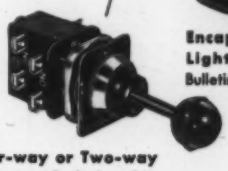
Among the many hundreds of Allen-Bradley push button and control units, you are certain to find the types best suited to your particular needs. The seven units shown below are a few of the latest additions to the Allen-Bradley *quality* line of control units.

All Allen-Bradley control units—standard duty, heavy duty, and oiltight—have double break, silver alloy contacts—to assure reliable operation. Simple constructions and generous wiring room are outstanding features. Insist on Allen-Bradley control units for *all* of your equipment—you can't go wrong!

NEW

**Illuminated Push Button.** Combines pilot light and push button in one unit. Oiltight Bulletin 800T.

**Push-to-Test Pilot Light.** Oiltight Bulletin 800T.

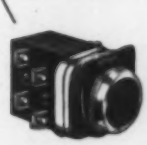


**Four-way or Two-way Selector Switch.** Oiltight Bulletin 800T.

**Encapsulated Pilot Light.** Heavy Duty Bulletin 800.

**Encapsulated Pilot Light.** Oiltight Bulletin 800T.

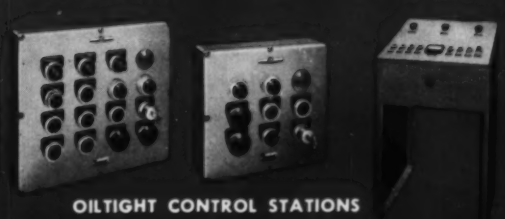
**Time Delay Push Button.** Delay is adjustable from 0.5 second to 5 seconds. Oiltight Bulletin 800T.



**Double Circuit Push Button.** Has 2 N.O. or 2 N.C. contacts. Oiltight Bulletin 800T.

STANDARD DUTY CONTROL STATIONS

HEAVY DUTY CONTROL STATIONS



OILTIGHT CONTROL STATIONS

ALLEN-BRADLEY OFFERS the most complete line of standard duty, heavy duty, and oiltight control stations on the market. Send for Publication 6090 today.

1-59-MR

# ALLEN-BRADLEY

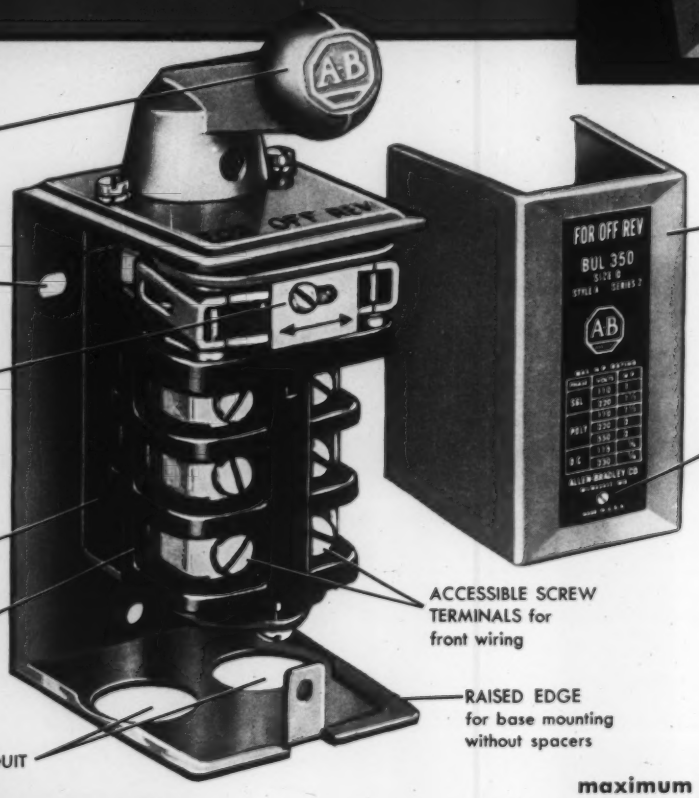
## MOTOR CONTROL

QUALITY

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

# A new "quality" standard for small REVERSING DRUM SWITCHES

A-B QUALITY




GOOD-LOOKING AND GOOD "FEELING" DIE CAST HANDLE

EASILY ACCESSIBLE MOUNTING HOLES

MERELY LOOSEN SCREW AND SLIDE PLATE to change from momentary to maintained contacts —or vice versa

INDEPENDENT SWITCH MOUNTING prevents misalignment

HEAVY CONTACT SURFACES for long operating life

TWO CONDUIT OPENINGS

WRAP-AROUND COVER gives complete access to drum

SINGLE SCREW COVER MOUNTING —screw cannot fall out

ACCESSIBLE SCREW TERMINALS for front wiring

RAISED EDGE for base mounting without spacers

**maximum rating 2 horsepower**

## NEW OILTIGHT COVER PLATE FOR CAVITY MOUNTING

Bulletin 350 Reversing Switch can be furnished with oiltight cover plate with rubber gasket seal for cavity mounting in a machine base.

This *all-new* Allen-Bradley reversing drum switch was designed to keep pace with the mechanical beauty designed into so many of the modern machine tools.

The Bulletin 350 reversing switch is equivalent to a three-pole, double throw switch . . . and can be used with d-c motors; or single phase, two phase, or three phase a-c motors.

Investigate the Bulletin 350 . . . the *new leader* of its class . . . in appearance, ease of installation, and operating life. An Allen-Bradley *quality* switch . . . in every sense of the word. Send for descriptive bulletin.

# ALLEN-BRADLEY

MOTOR CONTROL

QUALITY

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

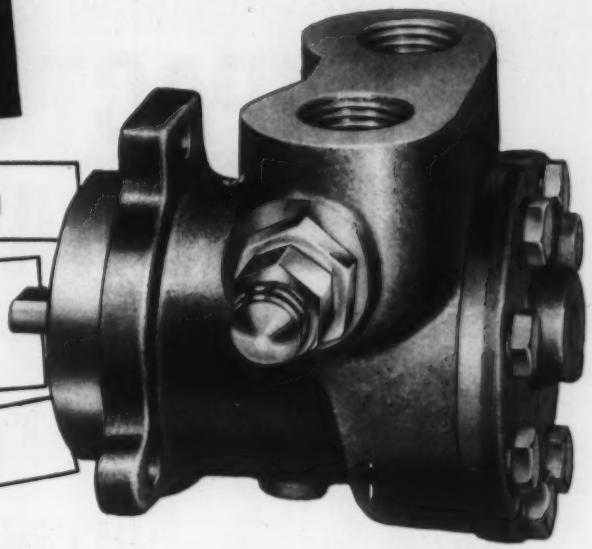
1-59-MR

# NOW

**Compact design**

**Complete mounting interchangeability**

**Built-in relief valves**



# on TUTHILL small industrial pumps

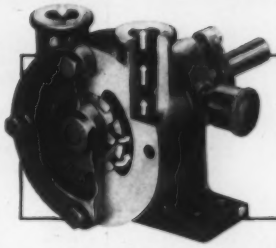
Now a new design—Series LPFV—gives you even greater flexibility with Tuthill small industrial pumps . . . the industry standard for dependable operation for many years.

Complete interchangeability allows the use of any one of five different sizes in the series on the same mounting arrangement. Capacities range from 20 to 360 gallons per hour, at pressures up to 500 psi. Normally provided for 1800 RPM, 3600 RPM speeds are permissible in most cases. And a built-in relief valve is now offered as optional equipment on all LPF models.

Compactness, an outstanding characteristic of all Tuthill pumps, is particularly exemplified in the new model LPFV with its shorter mounting hub. It is also available in close coupled motor-pump combinations for applications where space and weight are at a premium.

The newly designed model LPFV incorporates the performance-tested operating characteristics of Tuthill's internal gear construction described at right. In thousands of applications . . . in hydraulics, lubricating, transfer, circulating and other services . . . Tuthill internal gear pumps have established enviable records for reliability and quiet operation.

Over 700 models of Tuthill internal gear pumps are available to provide one especially suited to your application. These include stripped models for built-in applications, cartridge pumps, reversible models . . . a host of specialized pumps for each individual service. Mail the coupon today.



**TUTHILL internal gear pumping principle**

In Tuthill internal gear pumps, proven in 30 years of operation, there are only two moving parts. The principle is based upon the use of a rotor, idler gear and a crescent shape partition cast integral with the cover. Power applied to the rotor is transmitted to the idler gear with which it meshes. The space between the outside diameter of the idler and the outside diameter of the rotor is sealed by the crescent. As the pump starts the teeth come out of mesh increasing the volume. This creates a partial vacuum drawing the liquid into the pump through the suction port. The liquid fills the spaces between the teeth of the idler and the rotor and is carried past the crescent partition to the pressure side of the pump. When the teeth mesh on the pressure side the liquid is forced from the spaces and out through the discharge port.

Tuthill Pump Company
953 East 95th Street
Chicago 19, Illinois

☐ Please forward information on LPF series
☐ Please have your representative call

Name_____ Title_____

Company_____

Address_____

City_____ State_____

***Tuthill Manufactures a Complete Line of Positive Displacement Rotary Pumps in Capacities From 1 to 200 GPM; for Pressures to 1500 PSI; speeds to 3600 RPM.***

**TUTHILL PUMP COMPANY**

953 East 95th Street, Chicago 19, Illinois

For control of wear due to

# IMPACT and ABRASION

# AMSCO Ferrous Alloy Castings

## Types of Alloys Available

*Manganese Steels*—In addition to the standard manganese steel (Hadfield's analysis), Amsco produces four specially alloyed manganese steels. Chromium or molybdenum are added to improve yield strength, ductility and/or resistance to advance effects of heating.

*Chrome-Moly Steels*—Pearlitic, air-hardening steels alloyed with chromium and molybdenum are available in two forms. Both have higher tensile strengths and, in some applications, longer wearing properties than manganese steels.

*Multiple-Alloy Engineering Steel*—Martensitic, high-performance steel alloyed with chromium, nickel and molybdenum for use in combining engineering-abrasion applications. Develops very high tensile properties with good ductility and impact resistance.

*High-Chromium Iron*—Has excellent abrasion resistance with high compressive strength and low ductility.

Amsco® is the world's largest producer of austenitic manganese steel castings. This material—"the toughest steel known"—finds wide application in the mining, construction and quarry industries—wherever severe wear due to impact and abrasion is a factor.

In addition, Amsco produces nine other ferrous materials which vary widely in analysis, character and performance. This permits Amsco engineers to make an impartial recommendation on the *best* material for almost any specific wear application. Such recommendations normally require a careful appraisal of *all* factors affecting wear-life—including original cost, maintenance cost, service life, application characteristics.

Amsco engineers are equipped to give you specific information on the types of alloys listed here. Call in your nearest Amsco representative. Or write us direct for a copy of Booklet S-57—*Amsco Ferrous Alloy Castings.*

AMERICAN Brake Shoe COMPANY

# AMSCO

American Manganese Steel Division • Chicago Heights, Ill.

OTHER PLANTS IN: DENVER, LOS ANGELES, NEW CASTLE, DEL., OAKLAND, CAL., ST. LOUIS; JOLIETTE, QUEBEC

whatever the size... the type... the use...

YOU'LL FIND BCA BALL BEARINGS RIGHT FOR THE JOB!

For more than half a century BCA has been a primary supplier of ball bearings for original equipment to most of the leading manufacturers of passenger and commercial vehicles, tractors and farm implements.

Customers tell us that our engineering cooperation has enabled them to effect production economies and improve product performance.

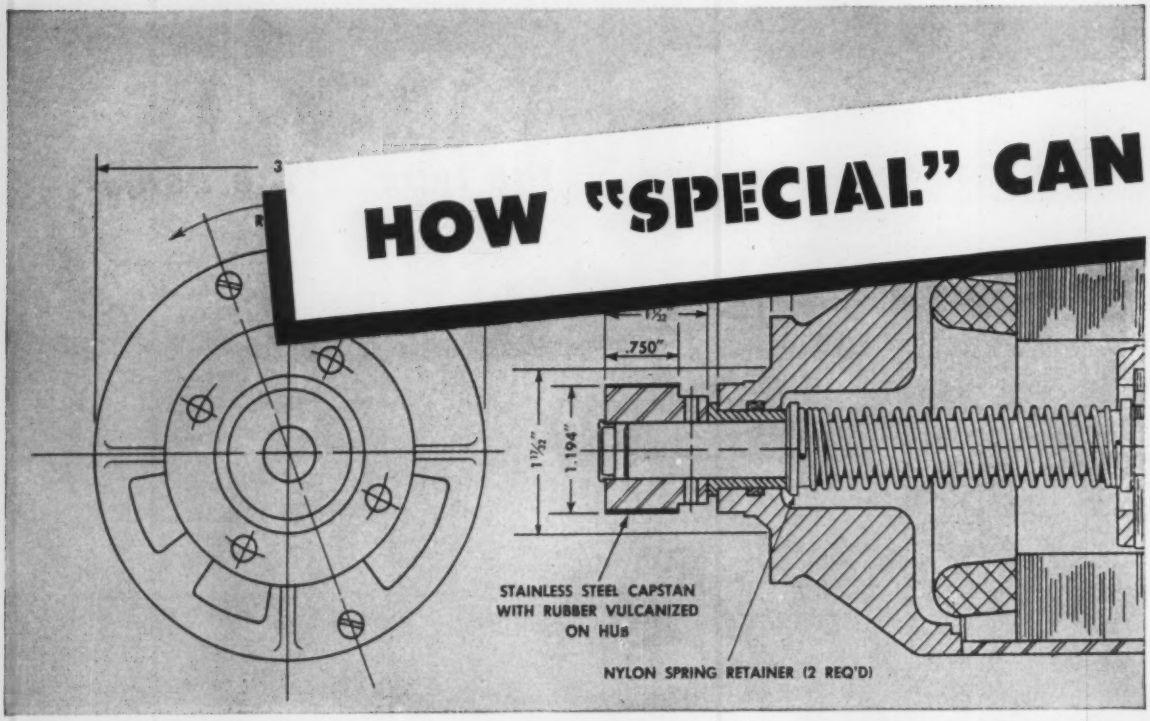
Over the years BCA has demonstrated production flexibility that assures prompt, as-promised delivery of emergency as well as routine requirements . . . in sample or production quantities.

BCA welcomes the opportunity to discuss with you any of your ball bearing applications or problems.

BCA

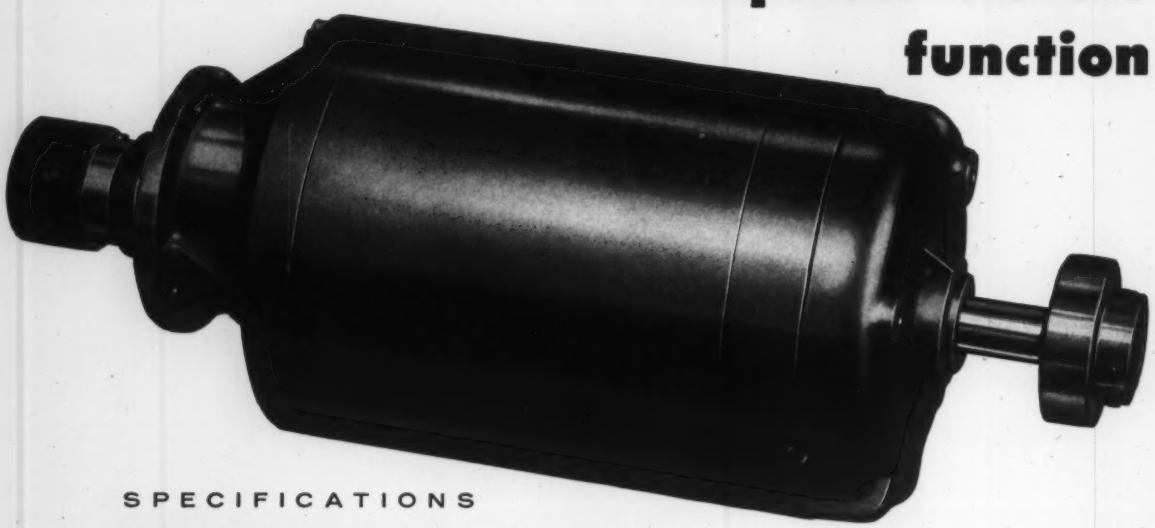
BEARINGS COMPANY OF AMERICA

Federal-Mogul-Bower Bearings, Inc.




# HOW "SPECIAL" CAN

# SPECIAL ROBBINS capstan motors function

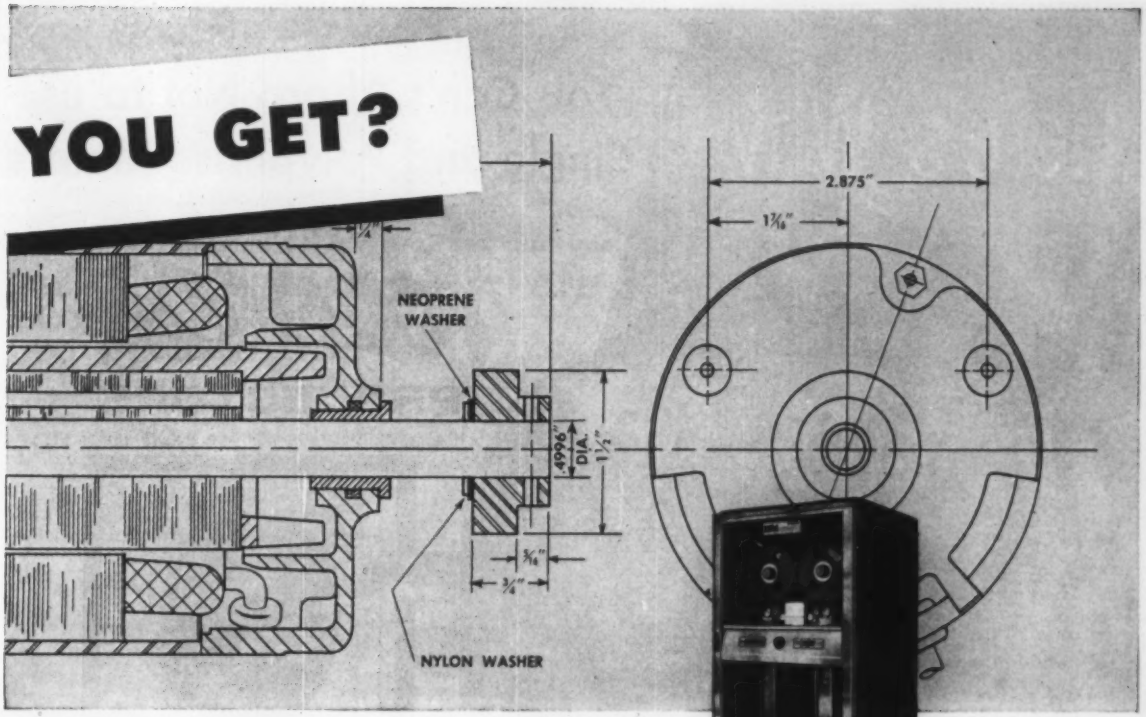


## SPECIFICATIONS

**Reluctance synchronous motor, 1/20 HP, 60 cycle, 3 phase, 208 volts ± 8%, 1200 RPM . . . Rotor dynamically balanced to commercial specifications . . . Shaft is shown in position when motor is stopped . . . When motor is running at synchronous speed, a minimum axial force of 350 grams is required with spring in place before displacement occurs . . . When rotor is in its retracted position and power is applied, the minimum axial force developed with spring in place is 100 grams . . . When power is cut off, the spring retracts the rotor with minimum 50 gram force while rotor is rotating.**

*Robbins & Myers builds motors from 1/200 to 200 horsepower*

# YOU GET?




# & MYERS
## accomplish unique
## in IBM'S 727 magnetic tape unit!

**SHAFT ROTATES AND MOVES AXIALLY**

Two of these special R&M motors are used in each of IBM's 727 Magnetic Tape Units. They answer IBM's need for a tape unit drive motor with a retractable capstan. The rotating shaft moves axially when the motor is started or stopped.

A spring holds the rotor, shaft and capstan in retracted position when the motor is stopped. When started, as the motor attains synchronous speed, axial force created as the rotor centers itself in the field becomes sufficient to overcome spring resistance. The capstan moves into engaged position and sends the tape reels rolling. Another capstan on the opposite end of the shaft (at right in drawing) actuates two microswitches as the rotor returns to retracted position when motor is stopped.

Four additional R&M fractional horsepower motors perform other high-speed power tasks within the tape units —driving reels, rewinding, unloading tape and retracting guide mechanisms.

R&M motors meet strict IBM engineering requirements: precise adaptability to special functions, capacity for lightning starts and stops, and absolute dependability. R&M can also design and build motors of highest quality designed to your exact specifications. For reliable fractional power, contact Robbins & Myers!

R&M

**ROBBINS & MYERS, INC.**
SPRINGFIELD, OHIO — BRANTFORD, ONTARIO

MOTORS · FANS · HOISTS · MOYNO PUMPS · PROPELLAIR FANS



Circle 446 on Page 19

# Here's Why···

## You Can't Afford Not to use Single and Polyphase Motors with KLIXON PROTECTORS

**Built-in Klixon Protectors in Single and Polyphase Motors Give You These Advantages**

- Elimination Of Motor Burnouts
- Increased Motor Output Under Adverse Conditions
- Simplified Motor Controls
- Reduced Motor Repairs And Replacement
- Reduced Production Down Time Due To Burned-Out Motors

KLIXON-Protected Motors are a sure way to keep today's rising operating and replacement costs down.

Built-in by motor manufacturers as an integral part of the motor, the KLIXON Protector saves money and reduces equipment down time by keeping motors operating at their maximum safe capacity under abnormal conditions. They enable you to get total output from your motors.

Built-in KLIXON Protectors safeguard your motors and prevent overheating and motor burnouts caused by the following conditions —

Prolonged overloads, unbalanced voltage, stalling, failure to start, increased ambient temperatures, lack of ventilation, plugging or reversing duty, single phasing.

Specify "KLIXON Protected Motors" on your purchase order . . . the savings are high . . . the advantages really worthwhile . . . the cost is low.

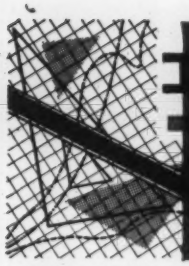
Full details may be obtained from your motor salesman; or write us for literature which explains the advantages of built-in motor protection.

**METALS & CONTROLS CORPORATION**
*Spencer Division*
3201 Forest St., Attleboro, Mass.

KLIXON®



Circle 447 on Page 19



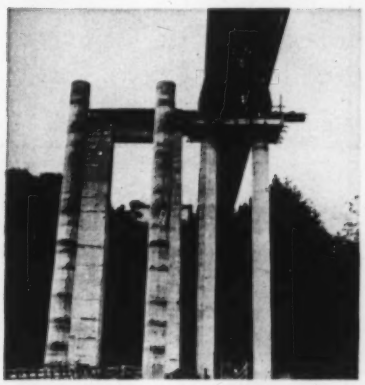
# Molykote® DESIGN news

## GERMAN ENGINEERS USE MOLYKOTE TO SLIDE 944 FOOT BRIDGE 60 FEET

The relocation of a bridge of these dimensions without the use of rollers has not previously been reported. The weight of the bridge was approximately 4,500 tons.

The results of extensive testing at the Bavarian Testing Institute at Nurenberg showed it to be more economical to move this bridge on girders lubricated with MOLYKOTE Type G than on rollers.

*When writing refer to Item 503.*



**This bridge carries traffic of the Munich-Salzburg Highway over the Mangfall Valley.**

## MOLYKOTE® OPERATES EFFECTIVELY OVER -300°F. TO 750°F. TEMPERATURE RANGE

**ATOMIC RADIATION DOES NOT AFFECT MOLYKOTE TYPE Z**

Extreme temperatures rule out the the use of conventional lubricants. They freeze solid at extremely low temperatures or form objectionable deposits at elevated temperatures.

The missile age has further complicated lubrication problems. Not only must lubricants operate over a wide temperature range, but they must be unaffected by radiation, be capable of functioning in a vacuum, be compatible with liquid oxygen, and have indefinite storage life.

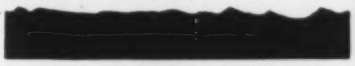
MOLYKOTE Type Z meets all of these requirements and is the only lubricant known to operate over a 1050°F. temperature range (-300° to 750°F.). In inert atmospheres, MOLYKOTE Type Z is unaffected by temperatures as high as 2000°F.

MOLYKOTE assures nearly 100% protection against galling and seizing on all low velocity extreme bearing pressure applications. With MOLYKOTE, the coefficient of friction decreases with increased loads and there is no tendency for it to be wiped away. The coefficient of friction with MOLYKOTE Type Z is .024 at 400,000 psi. MOLYKOTE maintains its effectiveness in the presence of all but a few strong acids. The problem of lubrication where abrasive dust contaminates the atmosphere is greatly reduced by MOLYKOTE dry films. MOLYKOTE Type Z conforms to MIL-M-7866A (ASG). It is the basic ingredient in the many MOLYKOTE types that are available to industry.

*When writing refer to Item 501.*

## NEW MOLYKOTE "WEAR IN" COMPOUND REDUCES SURFACE DAMAGE RESEARCH PROVES

During the critical wear in period, permanent surface damage, variously described as "galling", "scuffing", "scoring", "tearing", "scratching", "excessive abrasion", and "seizing", is an inherent hazard.



**Cross section of ground steel surface. (Redrawn to scale.)**

When magnified, even highly polished metals show surface irregularities as in the drawing above.

MOLYKOTE "Wear In" Compound was developed as a result of extensive research. It drastically reduces the time necessary to accomplish wear in and eliminates the hazards.

"Wear In" damage requires costly reconditioning of new equipment and the amount of damage left unrepaired has much to do with the useful service life of machinery.

*When writing refer to Item 502.*

## LIFETIME LUBRICATION WITH MOLYKOTE BONDED COATINGS

MOLYKOTE resin bonded lubricant coatings combine all the outstanding characteristics of MOLYKOTE with today's most advanced air-drying and thermosetting resins.

Roller Bearing Company, W. Trenton, N. J., process self-aligning bushings with a MOLYKOTE resin bonded coating. This coating provides lifetime lubrication and protection against corrosion.

MOLYKOTE resin bonded lubricant coatings are an amazing new development in the field of lubrication. They provide bearing surfaces with a wear-resistant film that has a low coefficient of friction. In many cases, the initial treatment is sufficient to lubricate parts for the lifetime of the equipment.

*When writing refer to Item 504.*

**Self-aligning bushing manufactured by Roller Bearing Corporation of America, W. Trenton, N. J.**

**THE ALPHA-MOLYKOTE CORP.,**
**Stamford, Conn.**
**Please send me details on**

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE

**Item 501** ☐ **Item 502** ☐
**Item 503** ☐ **Item 504** ☐

**Name** .....
**Company** .....
**Address** .....
**City** .....
**State** .....

Address your letter to The Alpha-Molykote Corp., 65 Harvard Ave., Stamford, "Research City", Conn. Phone: FIreside 8-3724.

BREAKING LUBRICATION BARRIERS ...THROUGH RESEARCH

**The Human Eye,** Nature's inspiration for the camera, can convert wavelengths of blue-green light measuring as little as 400 microns into visual perceptions that are truly life-size. Yet this entire human mechanism occupies space less than 1″ in diameter.

**Tiny New Potentiometer,** shown actual size, is designed to add space-saving precision to missile and aircraft servo mechanisms. Two MPB bearings in it assure accurate, low-torque shaft rotation — a vitally important benefit in sub-miniature components.

**Man With Miracles.** This is Maurice Hebert, one of MPB's Sales Engineers. He'll personally help you choose the correct MPB bearing to reduce friction and increase the precision of your instruments — while keeping your operating costs low with trouble-free service.

# Miracles in Miniaturization

ACTUAL SIZE OF THE MPB BEARINGS IN POTENTIOMETER SHOWN ABOVE

**The Smaller The Better** is often completely true. Engineers now know that miniaturization is the surest method of developing new or improved components for many of the latest developments in modern industry. But, as components become smaller, the problems of maintaining high precision and long service life become larger — and the call for MPB bearings constantly increases. MPB answers with the most experienced engineers in the miniature bearing industry, and advanced research facilities . . . producing over 500 types and sizes of bearings from ⅜″ O.D. down, with specials as required. We welcome your request for engineering advice, our catalog, or both.

**Write Miniature Precision Bearings, Inc., 201** Precision Park, Keene, N.H.

MINIATURE PRECISION

MPB

BEARINGS, INC.

*Helps you perform miracles in miniaturization*



*Circle 449 on Page 19*

# FALK Steelflex SPACER COUPLINGS
## save time and money in industrial operations

K and STEELFLEX are Registered Trademarks

## Cut disconnect-reconnect time by as much as 50%

The FALK Spacer Coupling is specially designed for quick installation or removal *without disturbing the driving or driven unit.* This feature can save you up to 50% in disconnect-reconnect time when critical equipment—a process pump, for example—needs repair or replacement.

Here's another saving: with the FALK Spacer Coupling, you can quickly realign shafts *without the usual loss of operating temperature!*

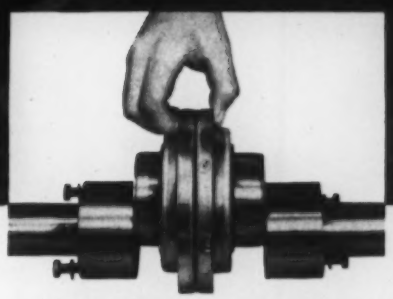
And still another: you can remove or reinstall the FALK Spacer as a unit *without draining the lubricant.*

Because of its exclusive grid-groove Steelflex design, the FALK Spacer can accommodate residual misalignment—parallel, angular, or (most important) *both.* Also, it provides torsional resiliency that cushions shock and vibration. Thus it saves wear-and-tear on your connected equipment.

To prove these claims and enjoy these savings, install a FALK Spacer on one application—and see for yourself. Consult your FALK Representative or Authorized Distributor.

**THE FALK CORPORATION, MILWAUKEE 1, WISCONSIN**
*MANUFACTURERS OF QUALITY GEAR DRIVES AND FLEXIBLE SHAFT COUPLINGS*
**Representatives and Distributors in many principal cities.**

**Circle 450 on Page 19**

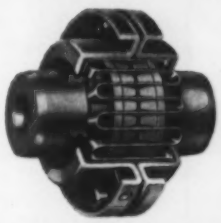


### EASY AND QUICK TO INSTALL, DISCONNECT OR RECONNECT

First, mount shaft hubs to allow proper distance between hubs; then, align driving and driven units.

Second, compress Spacer to fit space between hubs and tighten cap screws to pull spacer hubs into the registered fit.

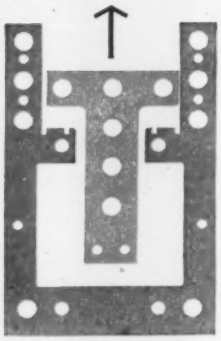
To disconnect, reverse the second step. No draining of lubricant necessary.



**The heart of the FALK Spacer ...the basic Type F Steelflex**
*Write for Service Manual 4838*

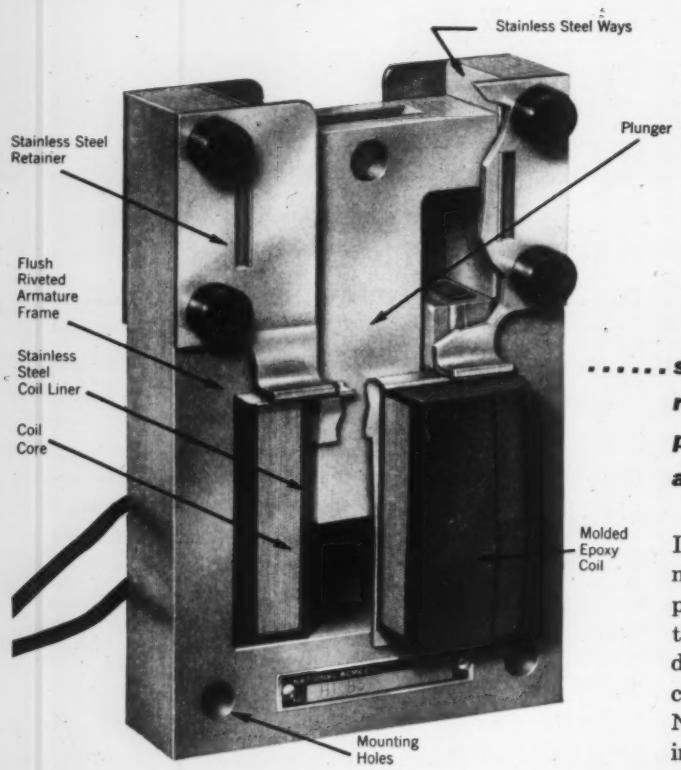
**FALK**
...a good name in industry

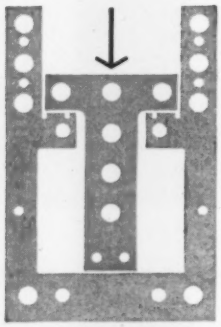
# SOLENOID CHATTER ELIMINATED.....



.....

## with the NEW NAMCO "H"-Series Solenoid



***.....so quiet in its closed position, so rugged, so adaptable to any design problem, your application headaches are reduced to mere details!***

Its noiseless holding operation permits solenoid applications never before considered practical. The usual chatter and clatter in the closed position is eliminated by a unique design that provides a positive three-point contact in the "holding position." Add to this Namco's stainless steel ways that provide improved performance and longer life; superior electromagnetic qualities, and the result is a *silent performer* you can't afford to overlook.

Namco standard solenoids are available in a wide range of pull and push types. Custom-engineered solenoids in every size capacity and type can be made to meet your specifications. Write us about *your* application problems stating specific requirements.

**National Acme**

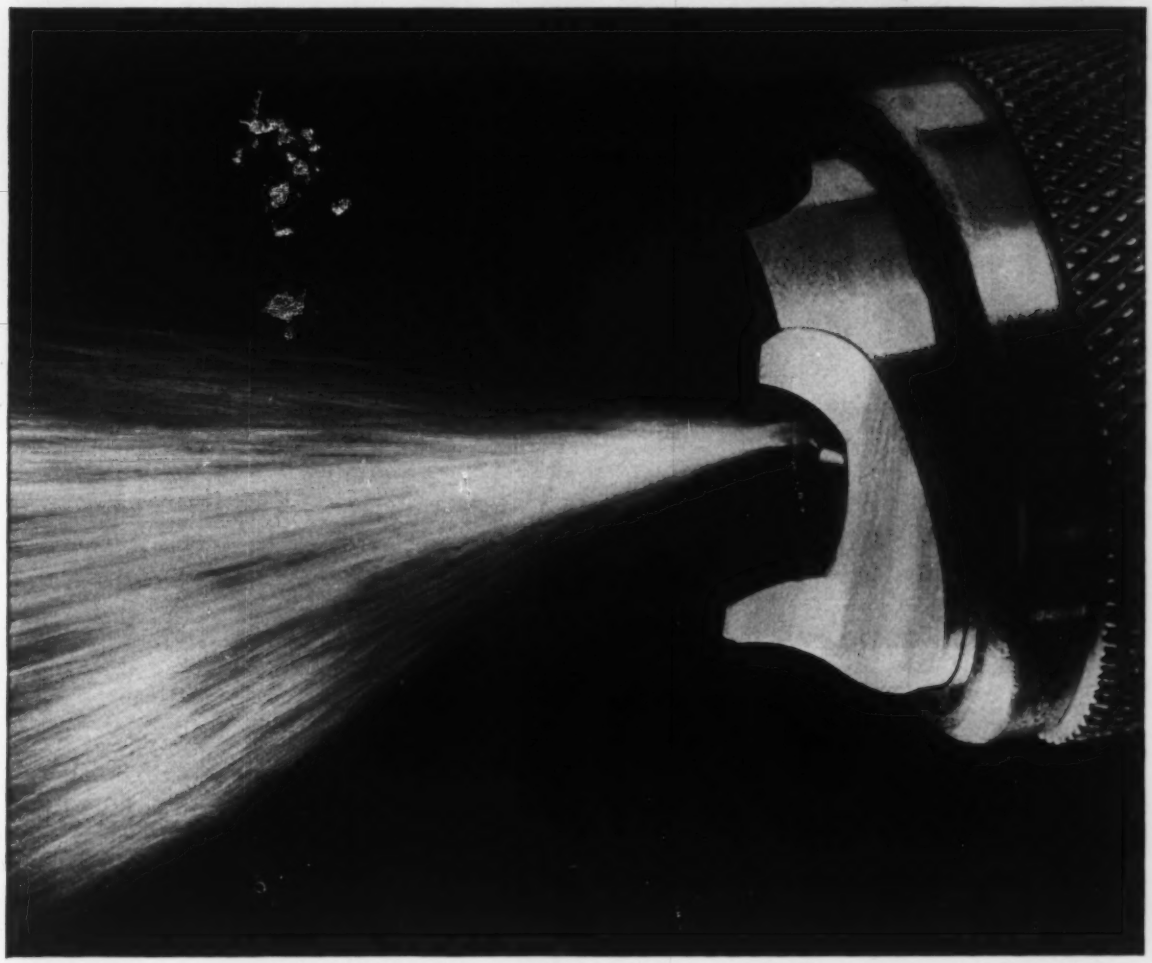
**THE NATIONAL ACME COMPANY**
**188 East 131st Street**
**Cleveland 8, Ohio**

**Sales Offices: Newark 2, N. J., Chicago 6, Ill., Detroit 27, Mich.**



*Circle 451 on Page 19*

# EC-1357 by 3M Sprays on Smoothly for Stronger Sandwich Bonds!



3M ADHESIVE EC-1357 MINIMIZES COBWEBBING IN SPRAY APPLICATIONS FOR BETTER SURFACE-WETTING, FAR BETTER ADHESION.

Solvent blending makes the big difference! Exact amounts of several solvents are skillfully mixed to achieve the precise blend required for a superior sandwich-bonding adhesive. The result: spray application is easier, greatly reduced cobwebbing saves materials, better surface-wetting provides far better skin-to-core adhesion.

With EC-1357, sandwich structures can be bonded on a cold press or nip roller to provide high ultimate strength.

For use with or without force-drying, EC-1357 can be adapted to the widest variation in production-line techniques and speeds. Good to excellent immediate bonding strengths are achieved, depending on the drying method used. Because it is dark-colored, EC-1357 absorbs infrared heat fast. For a similar, light-colored adhesive, investigate EC-1368.

The high moisture- and weather-resistance of EC-1357 and EC-1368, plus their capacity to hold fast through a wide temperature range, make them ideal in unusually severe climates.

**SEE WHAT 3M ADHESIVES CAN DO FOR YOU!** For technical assistance, contact any one of our 19 branch offices located in principal cities throughout the United States. Six plants provide local service for faster delivery. For free literature, write: A., C. & S. Division, 3M, Dept. Q-1, 900 Bush Avenue, St. Paul 6, Minnesota.

ADHESIVES, COATINGS AND SEALERS DIVISION

**MINNESOTA MINING AND MANUFACTURING COMPANY**

**... WHERE RESEARCH IS THE KEY TO TOMORROW**

3M COMPANY



*Circle 452 on Page 19*

# stitching together a giant radome

*Radome designed and built by Long Sault Woodcraft Limited, St. Andrews East, Quebec, for the United States Air Force RADC.*

Looking upward from the inside of the world's largest stressed skin sandwich radome built of translucent fiberglass panels, securely joined by hundreds of DUAL-LOCK fasteners.

Radar antennae along the upper perimeter of North America's defense system are enclosed by protective domes which stop ice, snow, and gales up to 150 mph.

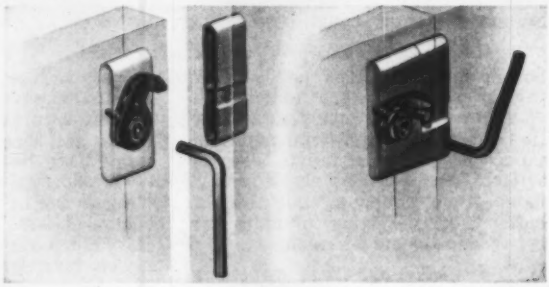
This precisely engineered pattern of fiberglass panels is erected quickly and surely, under the most adverse field conditions, using recessed Simmons DUAL-LOCK fasteners.

DUAL-LOCK is ideally adapted to panel fastening for military shelters, demountable shipping containers, aircraft cowlings and guided missiles.

Features:

- High load characteristics. The standard No. 1 DUAL-LOCK withstands 2500-lb. tension, and with modifications, tension loads of 7000 lbs. and over.
- Double-acting take-up provides great closing pressure, with minimum pressure on operating tool.
- Positive-locking. Trigger action insures fully open and fully closed positions.
- Vibration-proof and impact-proof. Will not accidentally unlock or loosen.

**Write for catalog #1257.** Complete specifications, drawings, details of DUAL-LOCK and other Simmons Fasteners with unlimited money-saving applications.



## SIMMONS FASTENER CORPORATION

**1756 North Broadway, Albany 1, New York** *See our catalog in Sweet's Product Design File*

QUICK-LOCK • SPRING-LOCK • DUAL-LOCK • ROTO-LOCK • LINK-LOCK • HINGE-LOCK

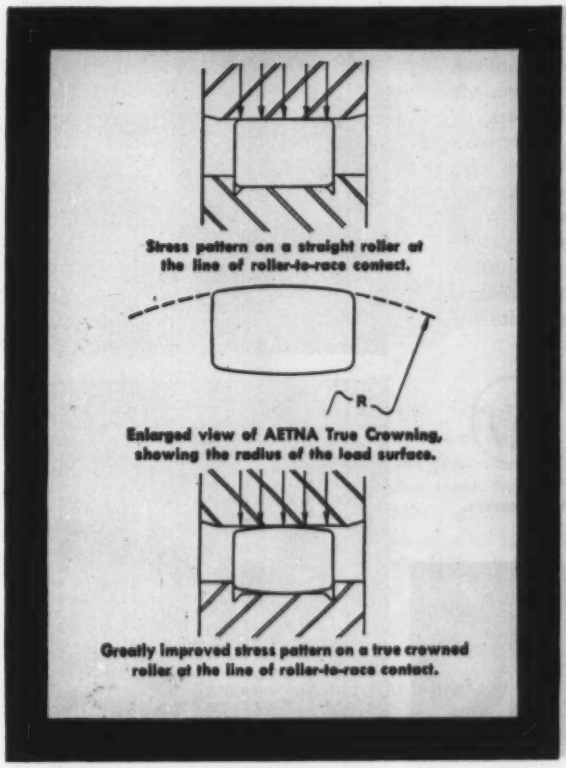
# Buy 10%-15% longer bearing life with

# Aetna TRUE CROWNED Roller Bearings

Competitive tests of AETNA *True Crowned* Roller Bearings with standard roller bearings by leading machinery builders on identical equipment, with identical load stresses, proved conclusively, time and time again, that AETNA True Crowned Roller Bearings have a 10% to 15% longer service life.

There is no premium for this True Crowned bearing surface. AETNA engineers recommend True Crowned rollers because this design provides the best distribution of stresses across the full length of the roller. You simply buy longer service life at the same cost by specifying AETNA.

*The reason for longer bearing life is apparent in these drawings:*




Stress pattern on a straight roller at the line of roller-to-race contact.

Enlarged view of AETNA True Crowning, showing the radius of the load surface.

Greatly improved stress pattern on a true crowned roller at the line of roller-to-race contact.

Each roller incorporated into AETNA Roller Bearings is carefully ground to a fine finish with a large radius to relieve the high stress point present where two cylindrical bodies are in rolling contact and under load. The crown radius is scientifically determined and varies with the size of the roller.

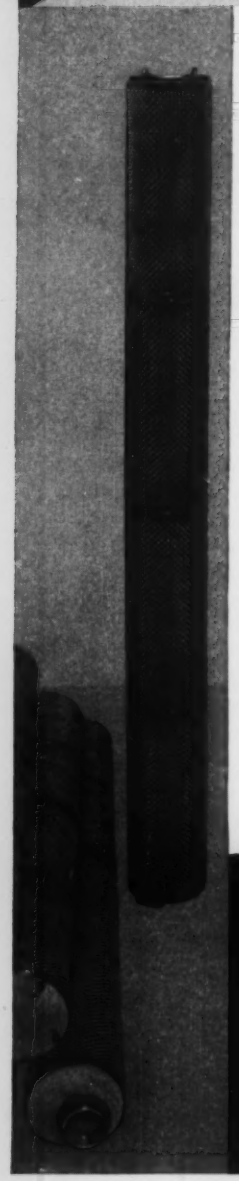
AETNA stocks pure radial cylindrical roller bearings, and is equipped to supply pure thrust or special types with standard, precision or super-precision tolerances in special alloys to give longer life to your products. Call your local AETNA representative listed in the yellow pages of your Classified Phone Book, or write today for General Catalog and Engineering Manual—new 15th Edition.

**Aetna AETNA BALL AND ROLLER BEARING COMPANY**

DIVISION OF PARKERSBURG-AETNA CORPORATION • 4600 SCHUBERT AVE. • CHICAGO 39, ILL.



Circle 454 on Page 19



## Who cares about your Wire Cloth Fabrications?

*CAMBRIDGE does . . .*

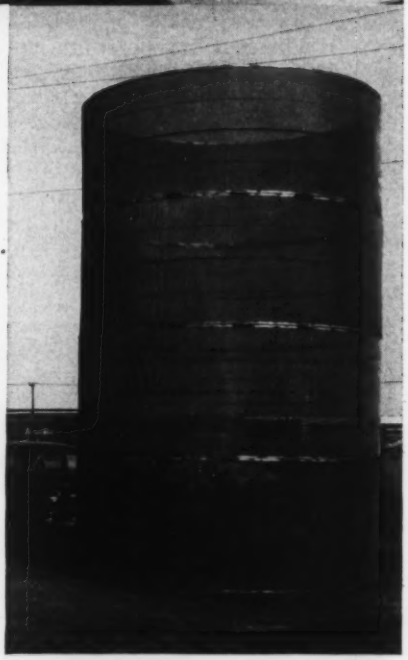
that's why you automatically get service with your order . . . whether you need dozens of midget strainers or a single giant-sized retaining screen.

Careful, competent workmanship and constant inspection assure you of quality . . . modern machinery and accurate scheduling assure you of prompt delivery. And, a Cambridge Field Engineer follows up your order to make sure our product is giving you the best possible service. Let us quote on your next order for wire cloth fabrications. We manufacture wire cloth from any metal or alloy—including titanium—in nine basic weaves. We'll work from your prints or draw up prints for your approval. Call your Cambridge Field Engineer . . . he's listed in the yellow pages under "Wire Cloth". Or, write for FREE 94-PAGE CATALOG.

**The Cambridge Wire Cloth Co.**

Department N • Cambridge 1, Md.

*Manufacturers of Wire Cloth, Metal-Mesh Conveyor Belts, Wire Cloth Fabrications*



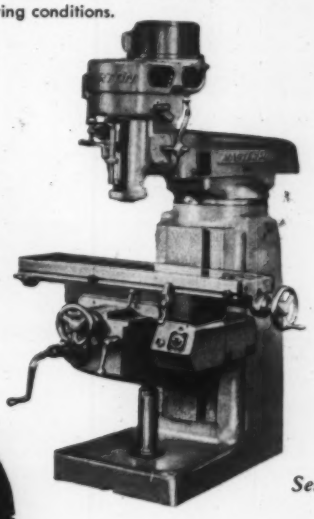
# Need Infinite Speed Adjustment—Accurate Control?

## Get Both with

# DYNAMATIC®

## FRACTIONAL HORSEPOWER AJUSTO-SPEDE® DRIVES

Parker Majestic No. 2 Universal Grinder is equipped with two Ajusto-Spede Drives. One drive, mounted on the headstock, rotates the work against the grinding wheel. Another drive operates the table feed. Both work speed and table speed are infinitely adjustable to suit varying conditions.



A Dynamatic Ajusto-Spede Drive provides infinitely adjustable table feed speeds on a Gorton Mastermil. Stepless adjustment permits the operator to select the proper table speed for maximum efficiency in machining all metals.

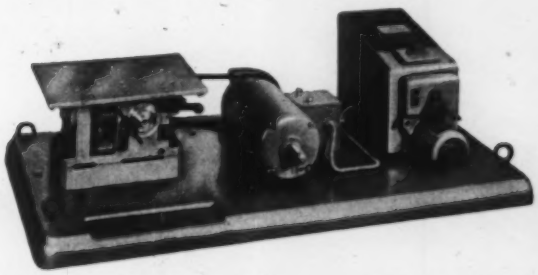
Wherever infinite adjustment and accurate control of speed are required for proper machine operation, satisfied users are realizing improved machine performance and product quality through the use of Dynamatic Ajusto-Spede Drives. Stepless adjustment from zero to full output speed, and accurate control of any speed within the range, permit operation at the exact speeds required.

Ajusto-Spede Drives operate on standard 115/220 volt alternating current, requiring no special power source. The compact drive with its integral control system needs no wall space, and requires little space on the driven machine. These drives may be mounted in any position, providing great versatility of application. Twelve models are available in ratings from ¼ hp at 1650 rpm through 1 hp at 3200 rpm.

Before you specify a fractional horsepower drive for your product or plant equipment, check the many advantages offered in the Dynamatic Ajusto-Spede Drive.

*Send for Your Free Copy of Illustrated Bulletin FAS-6 which Describes Dynamatic Ajusto-Spede Drives*

Harnischfeger Welding Positioner WP-1 uses an Ajusto-Spede Drive and gear reducer to rotate welding table. Table speeds are infinitely adjustable from zero rpm to 4.47 rpm. Drive tilts with table to the position desired by the operator.



Vibration Fatigue Testing Machine manufactured by the All American Tool and Mfg. Company employs an Ajusto-Spede Drive to operate a vibrating table at various speeds for testing instruments and electrical components.

EATON

# EATON

DYNAMATIC DIVISION
MANUFACTURING COMPANY
3307 FOURTEENTH AVENUE • KENOSHA, WISCONSIN



Circle 456 on Page 19

# THE OTHER DESIGN

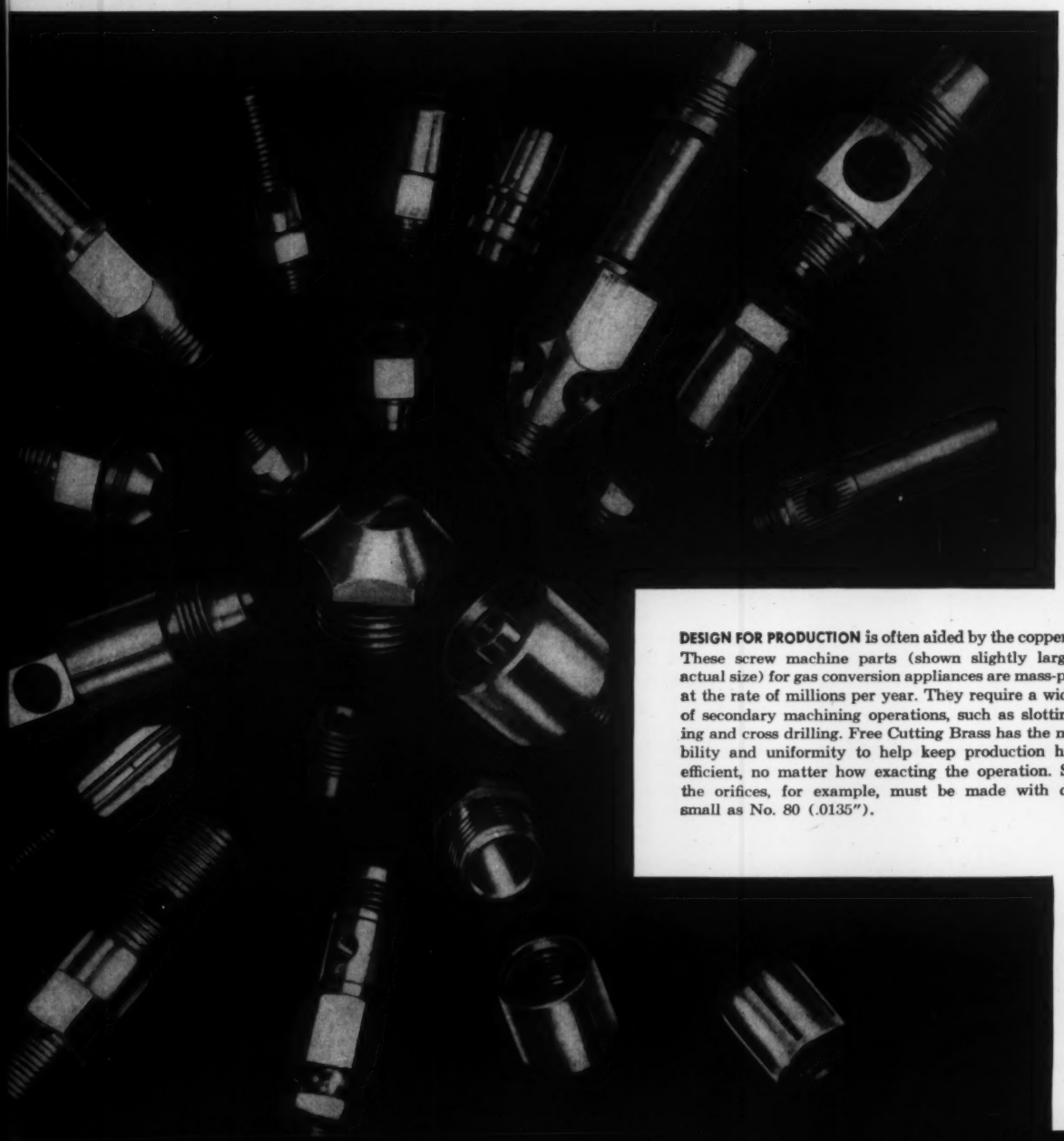
## How the copper metals can improve production as well as the product

How freely can you design for performance? How inhibited are you by the production requirements of your equipment and your materials?

When the materials of design are the copper metals, there are many ways, old and new, of converting the pilot model into mass production. In fact, the production versatility of these metals is as important as are their functional advantages. The facility of copper and its alloys for forming, machining, joining and finishing gives the product engineer greater latitude by helping him solve the *other* design problem — the problem of production.

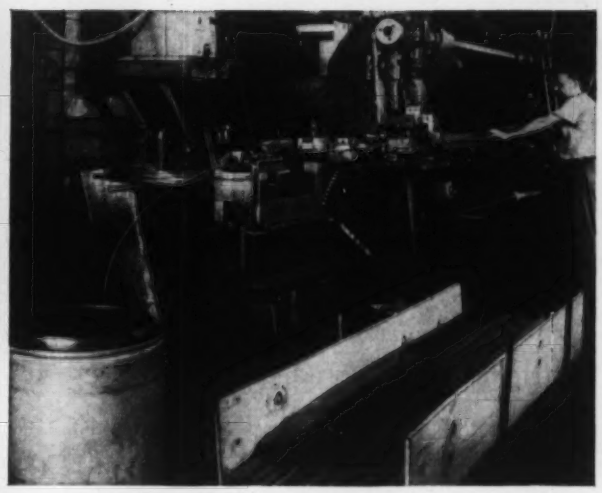
### Forming Methods

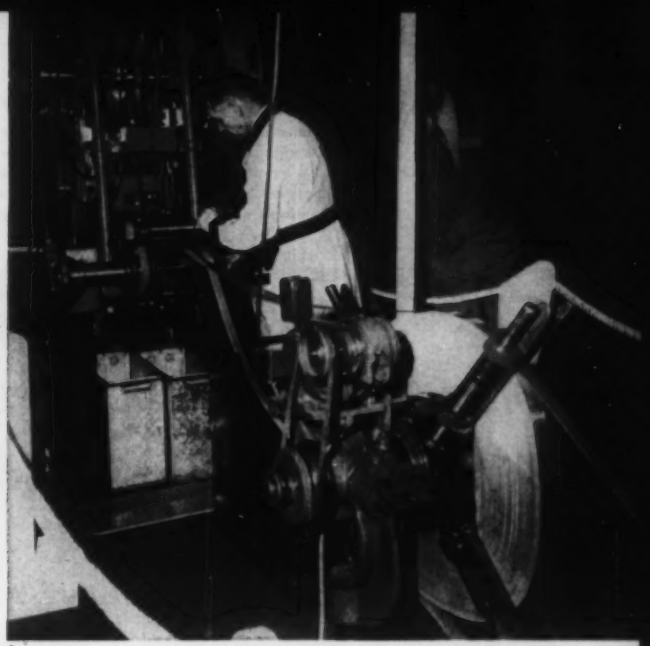
Various of the copper metals have the *ductility* for easy spinning, stamping, pressing, cupping and deep-drawing. They have the *malleability* for intricate and accurate forging, cold heading, coining, embossing, extruding, knurling, swaging, etc. Many are readily *machinable* at high speeds and feeds. They can be *cast* into large or intricate shapes. Copper and its alloys can be easily *soldered* — or, for even stronger



**DESIGN FOR PRODUCTION** is often aided by the copper metals. These screw machine parts (shown slightly larger than actual size) for gas conversion appliances are mass-produced at the rate of millions per year. They require a wide range of secondary machining operations, such as slotting, milling and cross drilling. Free Cutting Brass has the machinability and uniformity to help keep production high and efficient, no matter how exacting the operation. Some of the orifices, for example, must be made with drills as small as No. 80 (.0135").

# PROBLEM





**LESS DOWNTIME** and less handling result from longer lengths of brass mill products. The barrel-feed coils at left feed a continuous hinge machine for conversion to hinge pins. Long coils of strip above are being drawn into cups in the press.

joints, *brazed* with either silver-base or copper-base alloys. Many of the copper alloys can also be economically joined by modern methods of arc welding and oxyacetylene welding. Some of these methods are entirely automatic.

### Manufacturing Economies

A number of factors, besides easy forming, machining and joining, are resulting in considerable savings in the fabrication of the copper metals. These include reductions in manufacturing time due to preforming, reductions in scrap due to the availability of custom shapes from the brass mills, and the high resale value of the limited scrap produced.

Die-pressed forgings and special extrusions of precise cross-sectional form are among these important cost savers. For example, the brass yoke of the float valve shown at right was formed from an extrusion at a savings of 40%, in time and metal, over previous methods. An extruded shape costs more per pound than standard rod or bar, but the reductions in machining, forming and finishing costs may save you far more than the difference in initial price.

**CUSTOM EXTRUSIONS SAVE 40%** in the fabrication of this brass yoke for a ball-float valve. Custom extrusions like this save both metal and manufacturing time. They machine readily, are accurate in dimensions, and are available in long mill lengths to facilitate automatic operations.

**Circle 457 on Page 19**

### Automation Requirements

The copper metals can make automation more efficient. Machinability is one of the reasons. Many of the alloys can be milled at high speeds and feeds. Tools last longer and downtime is reduced.

Longer continuous runs are also made possible by the long lengths that the mills can now supply. The barrel-feed coils of wire and the extra-length coils of strip shown above are widely available. Greater-than-mile lengths of .005" gauge Cartridge Brass, 70%, for example, are frequently supplied for use in presses, eyelet machines or roll formers.

These recent developments in the copper industry, and the fabrication properties of the copper metals themselves, let you take full advantage of these metals by helping you to solve "the other design problem" — design for production. A 16-page reprint of "How to Get More for Your Metalworking Dollar — Copper and Brass" is available from the Copper & Brass Research Association, 420 Lexington Avenue, New York 17, New York.

*There's a new frontier in...*

**COPPER · BRASS**

**BRONZE**

# It's a tough life

*but the sensitive*

*Fenwal THERMOSWITCH® unit takes it in its stride*

Fenwal THERMOSWITCH Temperature Controls are enclosed in a tamper-proof assembly that's built to take grueling punishment — and stay highly accurate, uniformly sensitive throughout the operating range — *and its range is three to five times that of an ordinary thermostat!*

That means you can run your machine at greater speeds . . . your machine will require less maintenance! It means greater flexibility for your machine — greater sales for you — *and all at a low first cost.*

Even the assembly of a Fenwal THERMOSWITCH unit is easier and cheaper! The application of Fenwal THERMOSWITCH units are limitless — they're being used in planes . . . factories . . . ships . . . hospitals . . . homes . . . laboratories — *used almost any place where temperature is a factor and accuracy is a must!*

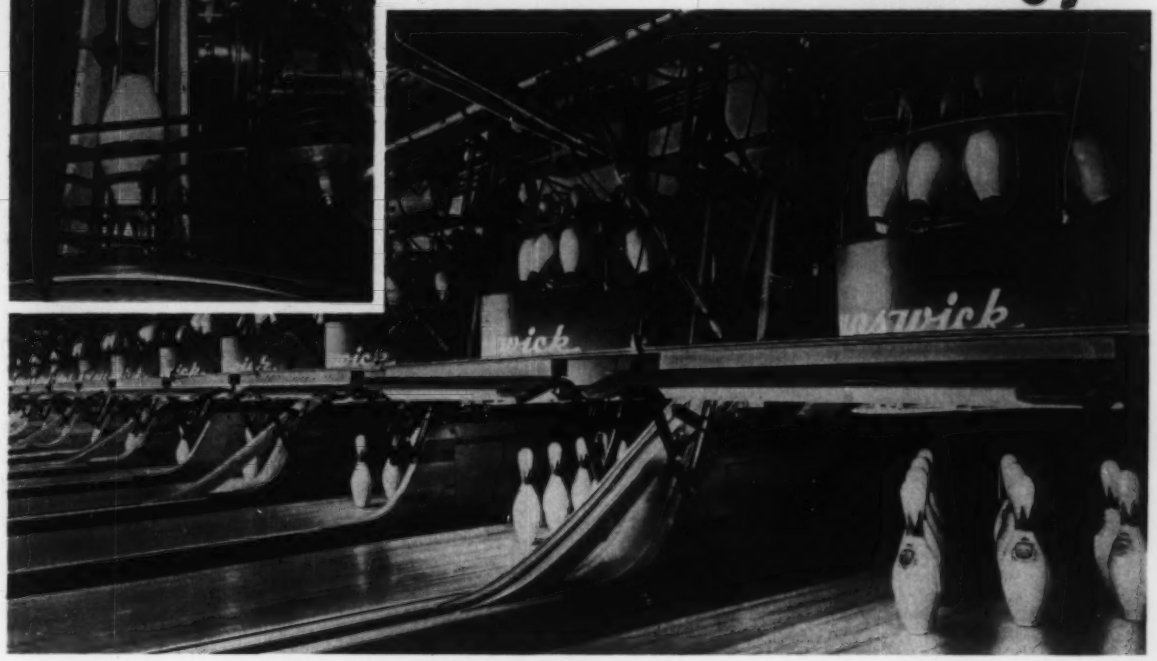
Drop us a line at Fenwal Incorporated, 191 Pleasant Street, Ashland, Mass. and we'll send you our catalog MC-135 or our sales engineer, whichever you want.

This is our 17000 series (we've got 25,000 other variations with the operating ranges from −100°F to 600°F) in use in Master Jet Frymaster. The Fenwal control gives the machine rapid, precise response; greater reliability — even makes it more economical by conserving cooking fat and gas!

Fenwal CONTROLS TEMPERATURE . . . PRECISELY

## Modern Automation revolutionizes age-old sport of bowling

**It's a far cry from the old "bowling alleys" and pinboys to today's ultra-modern, multi-lane bowling centers which attract millions of new bowlers each year. Much of this phenomenal growth and popularity dates from the introduction of automatic pinsetting machines which speed up the game, free it from dependence on pinboys and permit bowling around the clock.**



# Brunswick Automatic Pinsetters help maintain trouble-free precision with widespread use of ORANGE ROLLER BEARINGS

Few industrial machines can surpass the Brunswick Automatic Pinsetter for ingenious design—precision automation—or application of the most advanced mechanical principles and components.

In designing and selecting bearings for the many rotating, cam and oscillating motions in the pinsetter, Brunswick engineers worked closely with Orange engineers. From the wide range of Orange bearing types available, Brunswick obtained the most efficient type and construction of bearing for each specific requirement.

The solution to *your* bearing problems is as convenient as the Orange representative in your area. Call on him for engineering advice and information on Orange Roller Bearings.

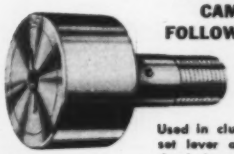
**Write for 40-page Engineering Reference Manual giving specifications on complete line of Orange Roller Bearings.**

**ORANGE**
**SEALED**
**Cage Type**
**NEEDLE BEARINGS**

Used in jogger arm assembly and pit conveyor vibrating arm.

**ORANGE**
**Full Type**
**NEEDLE BEARINGS**

Used in deck lift shaft assembly and in drive worm input shaft.



**ORANGE**
**CAM**
**FOLLOWERS**

Used in clutch reset lever and on the deck assembly.

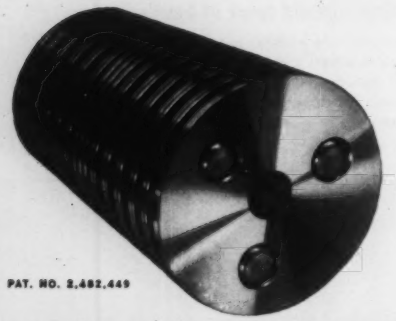
**ORANGE**
**CAM**
**YOKE**
**ROLLERS**

Used on scissor cam lever in gear box; also on rake shaft and as a rake cam follower.

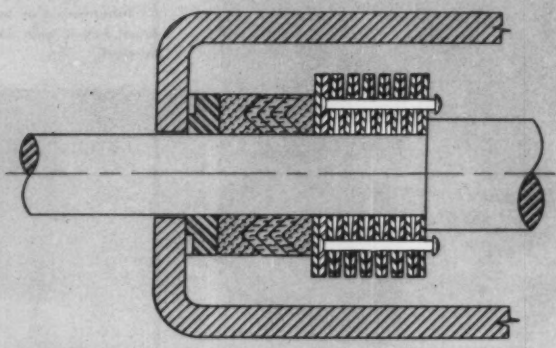
**ORANGE**
**ROLLER BEARINGS**

**ORANGE ROLLER BEARING CO., Inc.**
**556 Main Street, Orange, N. J.**

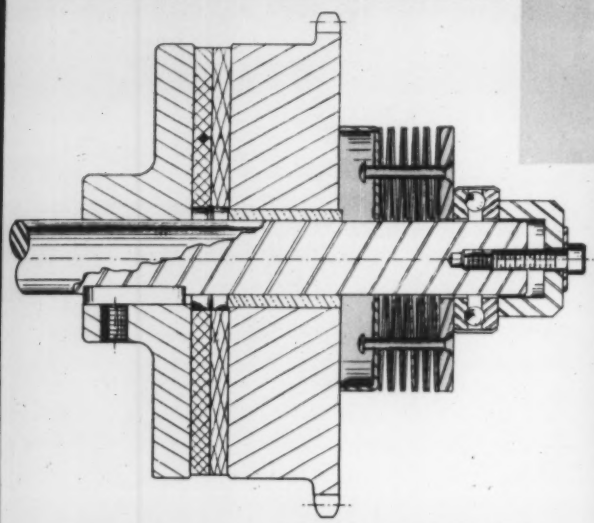
Needle Bearings — Staggered Roller Bearings
Journal Roller Bearings — Thrust Roller Bearings
Cam Followers



PAT. NO. 2,482,449



Typical installation of a "cartridge" of multiple Belleville washers in a shaft seal.



Typical installation of a "cartridge" of multiple Belleville washers in a clutch, such as in a machine tool drive.

# Some uses of Belleville Washers as a spring ENERGY CARTRIDGE

Where loads are high, operating space limited, and conventional spring forms fail to qualify, Belleville washers in the form of an Energy Cartridge can be a welcome solution. Two such conditions are illustrated here.

By preassembling the washers in a single compact unit held together by pins or posts, installation is simplified and error is prevented in stacking loose washers in sequence. For varying loads, many combinations are available: in series, parallel or parallel series.

Belleville washers may be used for vibration isolation, as spring mountings for punch and impact presses, or to maintain constant pressure. For further information, write for pamphlets "Belleville Springs" and "Energy Cartridge." For engineering and production assistance on large or small requirements, contact the nearest A.S.C. Division listed below.

## Associated Spring Corporation

9812

**General Offices: Bristol, Connecticut**

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
B-G-R Division, Plymouth and Ann Arbor, Mich.
Gibson Division, Chicago 14, Ill.
Milwaukee Division, Milwaukee, Wis.
Raymond Manufacturing Division, Corry, Penna.
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Cleveland Sales Office, Cleveland, Ohio
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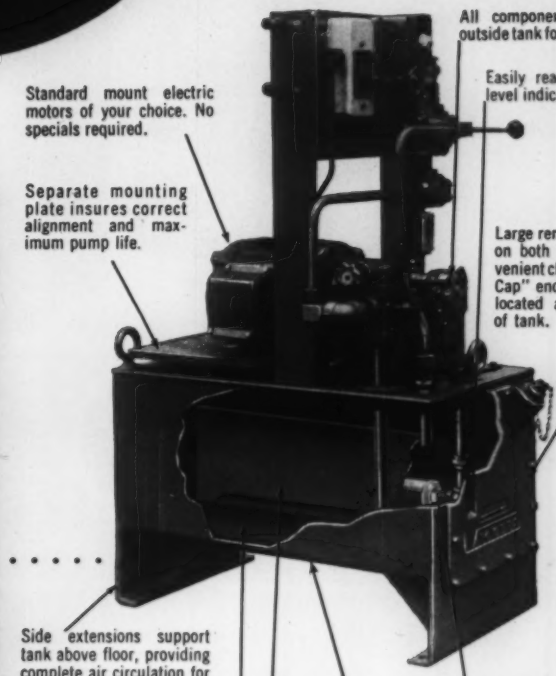
Canadian Subsidiary: Wallace Barnes Co., Ltd., Hamilton, Ont. and Montreal, Que. Puerto Rican Subsidiary: Associated Spring of Puerto Rico, Inc., Carolina, P.R.

*You save money and time applying Hydraulics when you buy the . . .*

**VICKERS** *package . . . . . instead of parts*

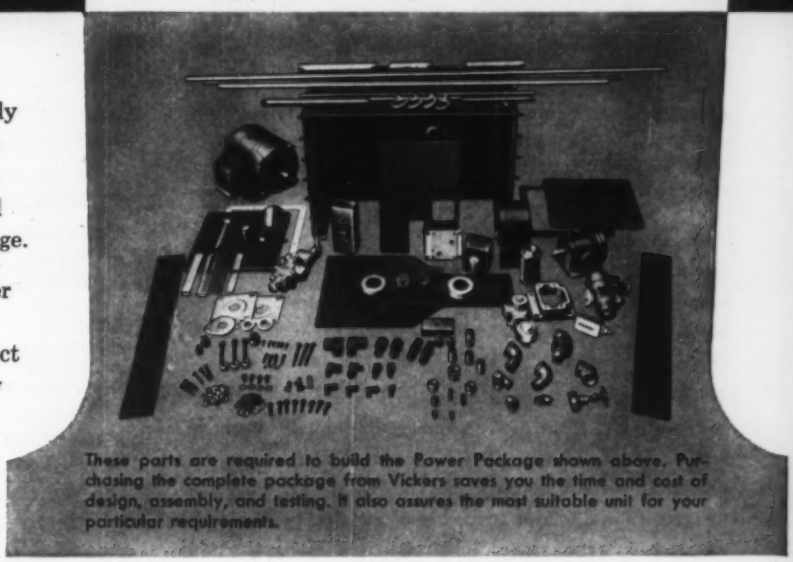

All components mounted outside tank for easy access.
Easily read accurate fluid level indicator.
Standard mount electric motors of your choice. No specials required.
Separate mounting plate insures correct alignment and maximum pump life.
Large removable covers on both ends for convenient cleaning. "Filler Cap" end cover can be located at either end of tank.
Side extensions support tank above floor, providing complete air circulation for maximum heat rejection.
Corrosion protection—internal tank surfaces sand-blasted and specially painted.
Inlet strainers can be removed and cleaned without disconnecting components or pressure piping.
New baffle plate improves fluid circulation.
Easy accessibility to drain plug.

Vickers Custom Built Power Package . . . complete . . . factory pretested . . . ready to connect and operate.

You save time and expense of design, layout, multiple purchasing, and assembly when you buy the Vickers package. You are assured of component compatibility and Vickers undivided responsibility and guarantee for the entire hydraulic package.

A Vickers Custom Built Hydraulic Power Package is a "complete unit" . . . factory pretested, ready for you to connect and operate. Designed and professionally built to your specifications.

*Call in a Vickers Application Engineer or write for Bulletin 5001B.*



These parts are required to build the Power Package shown above. Purchasing the complete package from Vickers saves you the time and cost of design, assembly, and testing. It also assures the most suitable unit for your particular requirements.

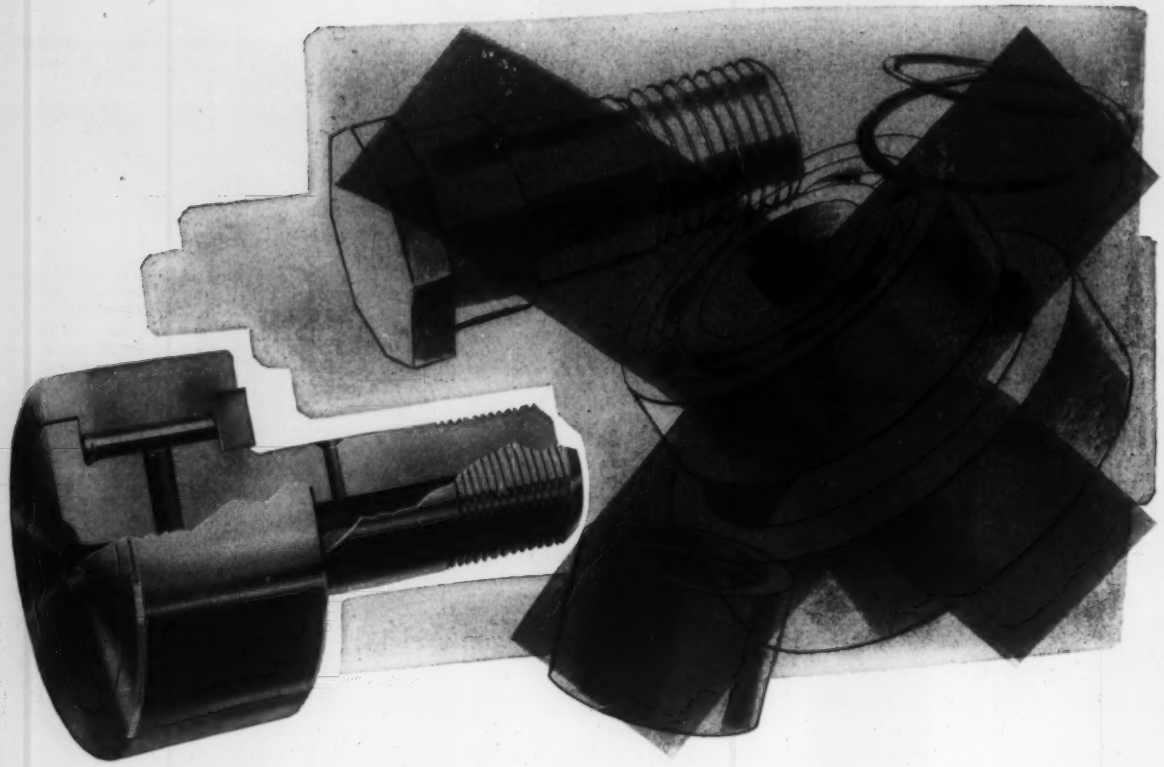
**VICKERS INCORPORATED**
DIVISION OF SPERRY RAND CORPORATION
**Machinery Hydraulics Division**
**ADMINISTRATIVE and ENGINEERING CENTER**
**Department 1430 • Detroit 32, Michigan**

*Circle 461 on Page 19*

Application Engineering Offices: ATLANTA • CHICAGO* • CINCINNATI • CLEVELAND • DETROIT* • GRAND RAPIDS • HOUSTON • INDIANAPOLIS • LOS ANGELES AREA (El Segundo)* • MILWAUKEE • NEW YORK AREA (Springfield, N.J.)* • PHILADELPHIA AREA (Media) • PITTSBURGH AREA (Mt. Lebanon) • PORTLAND, ORE. • ROCHESTER • ROCKFORD • SAN FRANCISCO AREA (Berkeley) • SEATTLE* • ST. LOUIS • WORCESTER • Factories also in: Australia, England, Japan and Germany • In Canada: Vickers-Sperry of Canada, Ltd., Toronto,* Montreal and Vancouver
Field Service Headquarters Underlined. Whse. Stock & Repair Branches*.

8155

**ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921**



# McGILL® CF *CAMROL*® bearings

## eliminate the cost of producing and assembling improvised cam follower, track and guide roller units

**THESE CAMROL ADVANTAGES SOLVE COST, DESIGN, PRODUCTION AND PERFORMANCE PROBLEMS:**

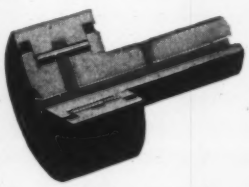
**• AVAILABILITY • INTEGRAL UNIT CONSTRUCTION • HIGH LOAD CAPACITY • SMALL RADIAL SPACE REQUIREMENTS • HIGH SHOCK RESISTANCE • PRECISION ACCURACY • SIMPLIFIED LUBRICATION**

You can simplify design and cut cost with CAMROL, precision cam followers. Procurement, production and assembly of components for improvised units are eliminated when you specify CAMROL bearings that are available from stock.

McGill developed the original roller bearing cam follower and perfected the CAMROL design through 25 years of application experience. Its full type construction provides exceptionally high capacity in an integral unit of a flanged, specially heat treated stud and heavy shock resistant outer race. Grease lubrication is simplified. Plain bearings require constant oil lubrication and bolt mounted ball bearings races crack under equivalent loads.

Precision construction, including concentricity of stud to outer race OD, provides accurate alignment of machine members. Ease of interchangeability and dependable operation in any cam action, track, guide or support roller application is assured. Use the CYR series in the same roller diameters for shaft mounting.

**PRE-LUBRICATED SEALED CAMROL BEARINGS**



These bearings combine the advantages of CF and CYR series bearings plus effective sealing against dirt, dust and grit. Ideal in applications where lubrication is a problem. Black ferrous oxide finish resists corrosion in contaminated areas.

CAMROL bearings are available in standard roller diameters from ½" to 4". Capacities to 20480 lbs. at 100 RPM.

**WRITE FOR FREE CATALOG NO. 52-A**

*engineered electrical products*

**McGILL®**

*precision needle roller bearings*

McGILL MANUFACTURING COMPANY, INC., BEARING DIV., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA



Circle 462 on Page 19

# You can machine them with confidence

When gears are made from Bethlehem forged-and-rolled blanks, machinists often report faster progress and a better finished job. The blanks are so sound, and have such excellent grain flow, that even the "touchiest" machining can be done with confidence.

Asked what he likes best about these blanks, a veteran production man answered, "They're easy to machine. When you're cutting teeth, you need metal that's clean and solid all the way through."

But there's another important advantage—*strength*. Bethlehem's forging-and-rolling process, unduplicated anywhere, assures the high strength always needed for heavy-duty products. Because of this, the blanks are unsurpassed for gears, crane and sheave wheels, turbine rotors, flywheels, pipe flanges, and other circular parts. Available heat-treated or untreated, they can be furnished in sizes from 10 to 46 in. OD. Write for Booklet 216.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

**BETHLEHEM STEEL**

BETHLEHEM STEEL



Circle 463 on Page 19

creative designing calls for an open mind

Leonardo Da Vinci's design for an odometer

Model courtesy of IBM

**EVEN DA VINCI'S ODOMETER COULD HAVE BEEN BETTER WITH HELP FROM AN SKF ENGINEER.**

An SKF engineer can afford to concentrate on your bearing problem rather than his own product line—because the SKF line includes all four types of ball and roller bearings in many thousands of sizes. This gives him the kind of flexibility he needs to keep an open mind on any bearing problem. Give your problem to SKF and see. 7836

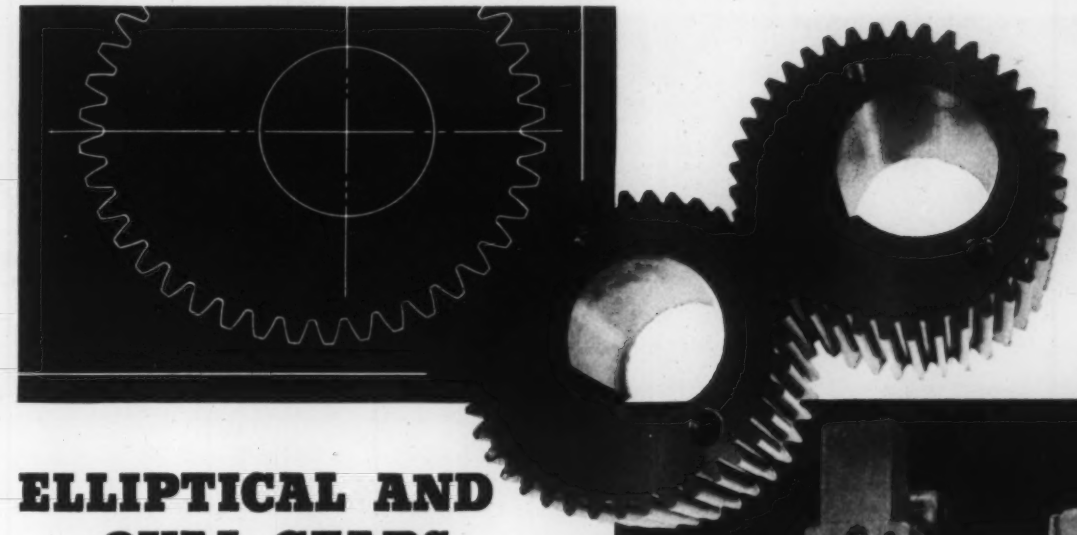
*Spherical, Cylindrical, Ball, and "Tyson" Tapered Roller Bearings*

EVERY TYPE—EVERY USE

SKF®

SKF INDUSTRIES, INC. PHILADELPHIA 32, PA.

*REG. U. S. PAT. OFF.

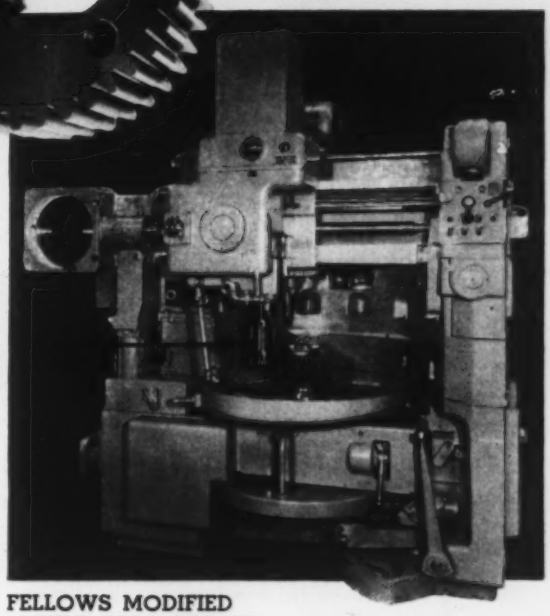


# ELLIPTICAL AND OVAL GEARS

## produced accurately and economically

Until now, owing to production difficulties, the design advantages of oval or elliptical gears have rarely been realized. Now Fellows has developed a unique method of generating these gears rapidly and economically. This new method minimizes the difficulty of wide variations in backlash experienced with such gears cut by previous methods. Full or modified involute teeth are produced to a higher degree of accuracy than was ever possible before on gears of this type. Production in any quantity is as simple as in cutting conventional cylindrical gears, once the setup has been made.

Fellows Modified 36-Type Gear Shaper generates elliptical or oval gears by continuously varying the center distance between cutter and gear during the cutting operation. A contour cam (A) and follower move the saddle the required amount in timed relationship with the rotation of the eccentric cutter-spindle adapter (B) to produce the gear pitch line contour.



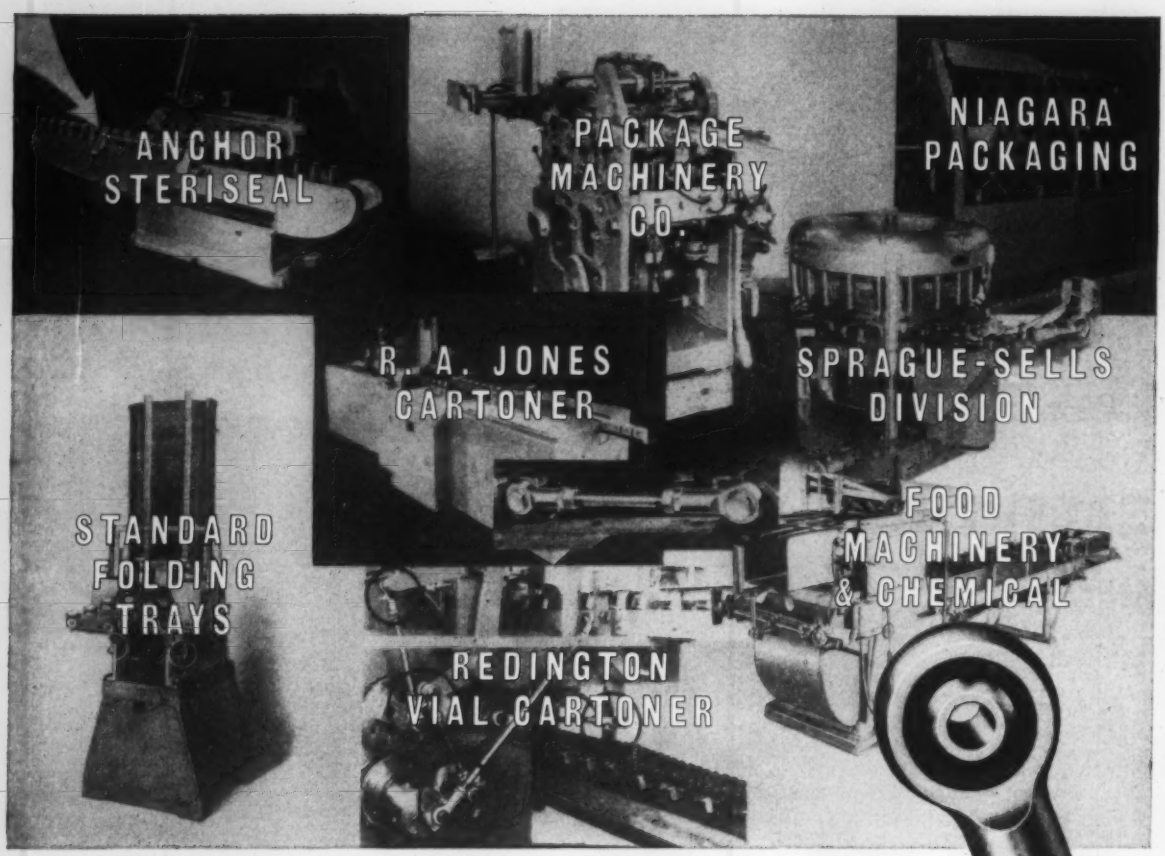
**FELLOWS MODIFIED 36-TYPE GEAR SHAPER**

In addition to *oval and elliptical gears* up to a maximum pitch diameter of 18", the Modified Fellows 36-Type Gear Shaper can produce a remarkable variety of *irregular contours* at high production rates. Two cams, a cutter-spindle adapter and a cutter are required for each gear or other shape specification. For further information, get in touch with any Fellows office.

THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont
Branch Offices:
1048 North Woodward Ave., Royal Oak, Mich.
150 West Pleasant Ave., Maywood, N. J.
5835 West North Avenue, Chicago 39
6214 West Manchester Ave., Los Angeles 45

THE PRECISION LINE

Fellows *Gear Production Equipment*




## Manufacturers of Packaging Machinery specify . . . .

# HEIM *Unibal* SPHERICAL BEARINGS AND ROD ENDS

Cartoning machines fold package inserts and assemble them with the bottle or vial, insert them in a carton and deliver the finished package ready for shipment.

Rotary Fillers draw liquid or semi-liquid materials into a cylinder and discharge them, in accurately measured amounts, into containers.

Casers assemble a load of cans, and insert the load into a case — at unusually high speeds.

The Steriseal machine is used for high production steam vacuum sealing of glass containers.

Bottles, jars, tubes, and a variety of articles are fed from the labeling machine to the cartoner which opens the folding box, inserts the contents, then tucks and delivers the complete package.

The Cigar Wrapper-Bander cellophane wraps and bands cigars faster than two a second.

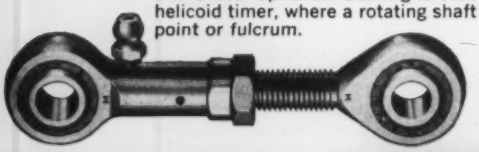
Folding trays, for tomato packaging and other types of fruits and vegetables, are formed from flat stock.

Imprinting of the package is done in one pass through some machines.

The motions involved in the push-pull linkages of this automated machinery are intricate and ingenious. Heim Unibal Spherical Bearing Rod Ends are used where it is necessary to correct inherent misalignments, and where close accuracy of fill and smooth operation at each station are mandatory.

They are used as suspended bearing supports for belt rollers. They change motion from vertical to horizontal plane, and vice versa.

The Unibal Spherical Bearing is exactly right as the support on one end of a helicoid timer, where a rotating shaft moving in all directions requires a focal point or fulcrum.



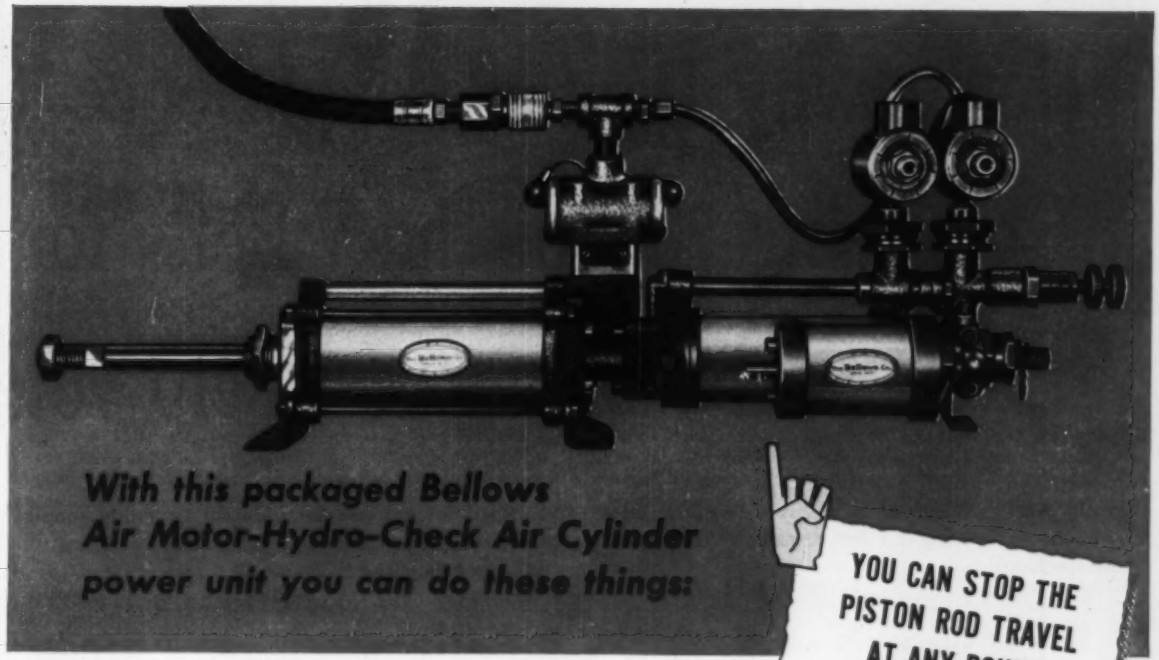
Quick and simple push-pull linkage assemblies are possible with one female threaded and one male threaded Unibal rod end. There is practically no limit to the length of linkages possible.

WRITE FOR CATALOG WHICH GIVES COMPLETE DATA, OR LET OUR ENGINEERING DEPARTMENT HELP WORK OUT DETAILS OF YOUR APPLICATIONS.

## THE HEIM COMPANY

FAIRFIELD, CONNECTICUT

# HOW TO "INCH" AN AIR CYLINDER



**With this packaged Bellows Air Motor-Hydro-Check Air Cylinder power unit you can do these things:**

YOU CAN STOP THE PISTON ROD TRAVEL AT ANY POINT, OR AT AS MANY POINTS AS YOU WISH

YOU CAN "INCH" IT ALONG JUST AS WITH AN ELECTRIC DRIVE

YOU CAN CHANGE THE SPEED OF THE PISTON ROD TRAVEL FROM FAST TO SLOW AND BACK

You can set it up for single cycle control or synchronize it with related elements for repeat cycling with precision accuracy. This Bellows Air Motor-Hydro-Check unit is available in standard stroke lengths up to 18" and in five bore sizes: 1¼", 1¾", 2½", 3⅝", and 4½".

Not all pneumatic applications require the range of control provided in this Bellows unit, of course. But, regardless of the type of control you require, you can obtain it in Bellows Air Motors, and usually in the form of one compact, complete, packaged unit — simple to install — doubly simple to control.

## THESE BULLETINS CONTAIN THE STORY

Bulletins BM-25 and HC-602 give full details on Bellows Air Motors and Hydro-Checks and the Bellows System of Air Control. There's no charge. Write Dept. MD-159, The Bellows Co., Akron 9, Ohio. In Canada, Bellows Pneumatic Devices of Canada, Ltd., Toronto 18, Ontario.

**The Bellows Co.**

DIVISION INTERNATIONAL BASIC ECONOMY CORPORATION

AKRON 9, OHIO

1125-B

# Here's why Dayton's experience in supplying 76% of the V-Belts for Variable Speed Drives can help you

Virtually every problem present on *any* V-Belt drive must also be met in building a V-Belt to meet Variable Speed Drive specifications.

In addition, two problems must be overcome, whose difficulty of solution puts V-Belts for variable speed use on the highest level of V-Belt design. These two problems are:

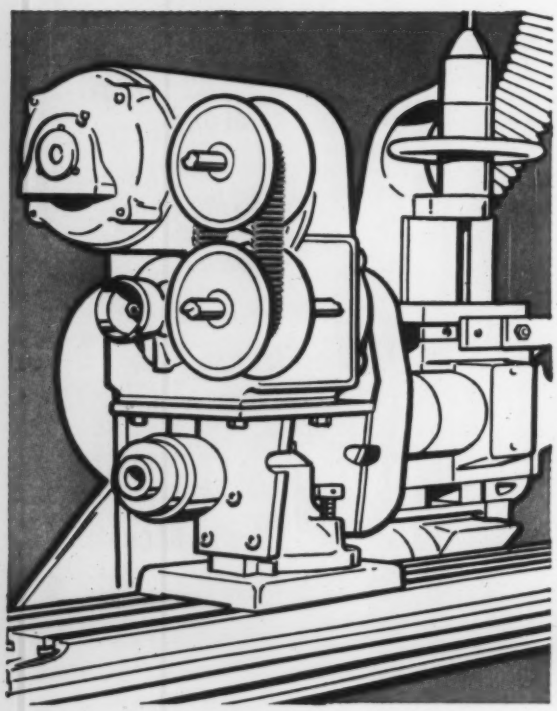
**1. Need for extreme longitudinal flexibility coupled** with tremendous transverse rigidity to accommodate sub-diameter pulleys and maximum axial pressures, and,

**2. Need for a V-Belt of minimum width and thickness** capable of meeting the requirements of a full speed range plus the ability to maintain exact speeds at each level.

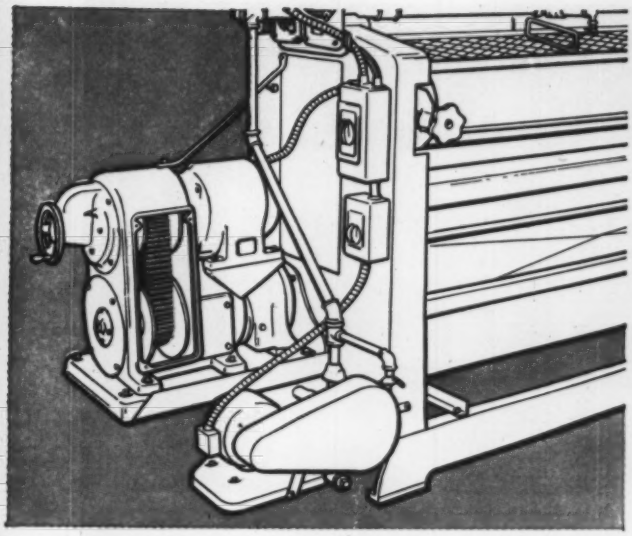
The ever-increasing market for variable speed drives of higher capacities and greater speed ranges requires a continuing program of V-Belt development. One of the most successful V-Belt designs resulting from this program is the exclusive Dayton Variable Speed Cog-Belt.*

The Dayton Cog-Belt is the closest approach to the theoretical ultimate in V-Belt design, offering the highest pull-out torque of any V-Belt made. For its effective depth it provides a higher degree of longitudinal flexibility than any other V-Belt design and is capable at the same time of withstanding maximum axial pressures. These are among the reasons it is especially adaptable to variable speed service.

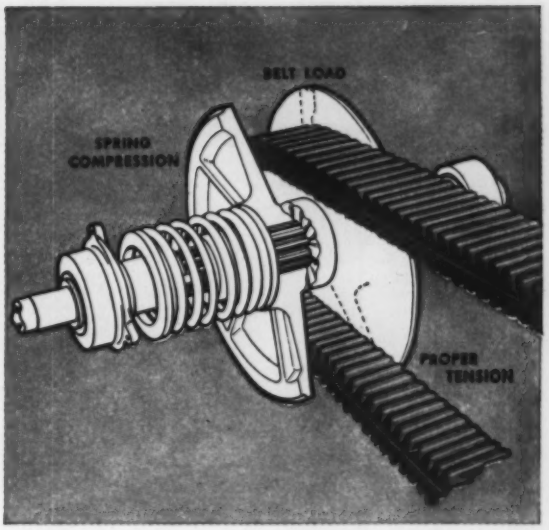
Variable speed drive manufacturers have, *through experience,* become convinced of the tremendous worth of Dayton's exclusive V-Belt designs and Dayton's skill in developing internal constructions to meet high and rigid requirements. As a result, Dayton supplies 76% of the V-Belts for the variable speed market.



For this rugged sheet metal press, Dayton Double Cog-Belts provide maximum longitudinal flexibility, extra strength and durability to take the high loads, high starting torques of the horizontal Variable Speed drive motor. Exclusive Double Cog design permits use of minimum width pulleys.



Vertical variable speed motor on this automatic Glue Spreader receives full, non-slip power from Dayton Variable Speed Cog-Belts. Exclusive double Cog design offers instant speed changes, assures maintenance of constant speeds for all operations.




Tremendous crosswise rigidity is provided by Dayton Double Cog-Belts to maintain precise speed control. Greater surface area rapidly dissipates heat of flexing, prevents heat build-up. Light weight reduces centrifugal forces and internal stresses.

## Dayton's experience in building special V-Belts extends into every major field of V-Belt drive design.

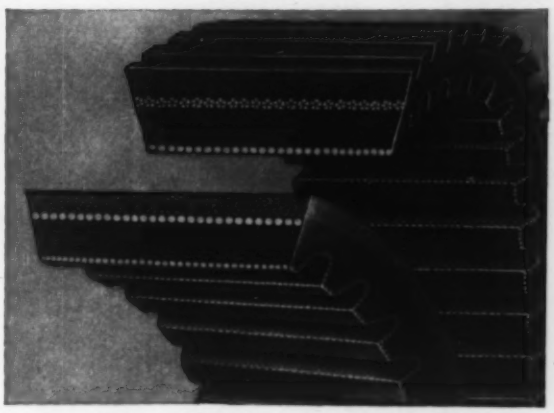
**In agriculture,** heavy duty variable speed drives are used as traction drives on self-propelled farm implements.

**In railway,** V-Belts for under car drives for lighting, heating and air conditioning, are required to meet a whole new set of conditions, among them being extremes of weather, misalignment and continuous service.

**In household appliances,** Dayton is expert in designing and producing FHP V-Belts which will give long, efficient service with almost no maintenance.

**In industry,** conditions which require special belts vary from the space and weight limitations of machine tool manufacturers, to the "full surge" loads which hit a set of V-Belts when peak power is applied instantaneously.

**For the answer** to your drive problem, whatever it is, contact the V-Belt manufacturer who supplies 76% of the toughest V-Belt drive market in the world — The Dayton Rubber Co., Ind. O.E.M. Div., Dayton 1, Ohio.



Dayton's exclusive Cog design operates at maximum efficiency over the widest range of speeds. Still, it lends maximum crosswise rigidity to prevent squashing under heavy impulse loads. With surer gripping raw edges, Dayton Variable Speed Cog-Belts are double assurance of accurate control at all speeds.

*TM

# Dayton Rubber

WORLD'S LARGEST MANUFACTURER OF V-BELTS

**Industrial Sales Engineers in Atlanta, Chicago, Cleveland, Dallas, Dayton, Minneapolis, Moline, New York, San Francisco and St. Louis**

# How can your customers Know ...unless your product can COUNT?

**H**ow can they know that they're getting out of your product all the performance you build into it — unless you *also* build into it a Veeder-Root Counter as a standard part? Then they have a running record of performance that shows them where they stand every minute of the working day . . . and a record that proves your product's guarantee. What's more, it gives you a new plus in selling.

How to build it in? Count on us to show you. Write, or phone JAckson 7-7201.

*You always "Know the score" when you count on Veeder-Root!*

**Vary-Tally Multiple Unit Hand-operated Counter.** Easy keyboard action. All units on same row reset instantly to zero with one turn of knob. Supplied in practically any number of units, in any arrangement.

**New High-Speed Predetermining Counter,** Series 1522, features instant lever reset plus quick and easy setting of predetermined number. Speeds up to 6,000 rpm. Also supplied without predetermining feature.

**New "Count-Pak",** a complete electronic counting package for use where high speed, long life and instant reset are required. Rated at 20,000 counts per minute (with added decade speeds run up to 200,000 cpm). *Completely transistorized.* Photohead adaptable to any job. Several other "Count-Paks" available.

*Everyone can Count on*

**Veeder-Root Inc.**

HARTFORD 2, CONNECTICUT

Hartford, Conn. • Greenville, S. C. • Altoona, Pa. • Chicago
New York • Los Angeles • San Francisco • Montreal
*Offices and Agents in Principal Cities*



Circle 469 on Page 19

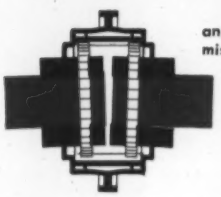
# LINK-BELT motor couplings...

## geared for top economy and long wear

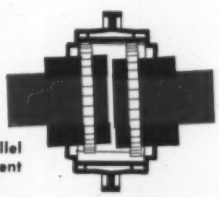
# NEW!

**Durable, lightweight design** consists of two externally geared steel hubs, which engage flexibly with an internally geared steel sleeve — all enclosed in a protective two-piece metal cover. Synthetic rubber O-rings and felt hub seals effectively retain lubricant and exclude outside contamination.

## Misalignment protection



angular misalignment



parallel misalignment

**Link-Belt Motor Couplings accommodate free angular and parallel misalignment.**

**Now you can afford flexible geared couplings on small electric motor applications.** New Link-Belt MC motor couplings are *geared* couplings—the established standard of performance throughout industry. And at a new *low price*, these couplings are no longer too expensive for smaller motor applications.

High capacity and durability are embodied in the all-metal design. Assembly or disassembly is quick and easy . . . fast-acting quarter-turn spiral cam fasteners are a permanent part of the cover. No loose nuts or bolts.

Equipment manufacturers will discover special economies in Link-Belt MC couplings—they are excellent for such equipment as speed reducers, pumps and generators. Available "off-the-shelf" for shafts up to 1⅞". Contact your nearby Link-Belt office.

**Write for Folder 2875**—Gives detailed information and specifications on the new Link-Belt MC motor coupling.

14,950

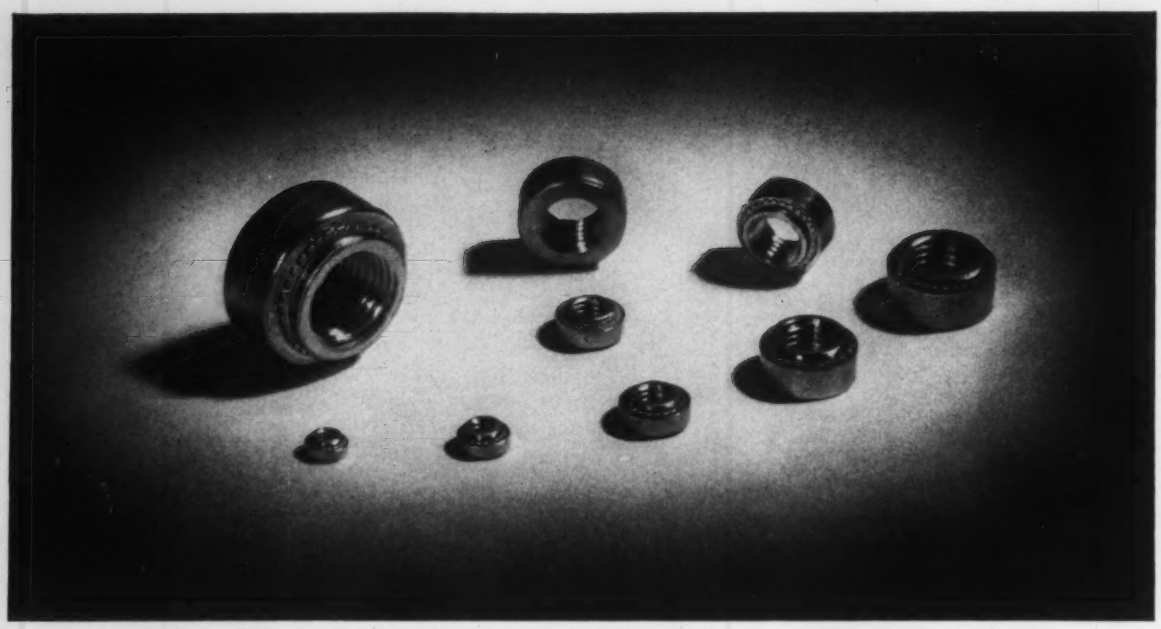
LINK-BELT

GEARED FLEXIBLE COUPLINGS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.



Circle 470 on Page 19



**New SPS Swage Nuts** can be installed quickly and easily in a wide range of sheet metals, including steel, without use of special tools or dies. They provide handy tapped holes in thin-section assemblies, aid in blind fastening.

# New SPS Swage Nuts simplify problem of putting load-bearing threads in sheet metal

SPS Swage Nuts offer you a fast, economical means of putting load-bearing threads in thin metal. Unlike similar fasteners, they require no special tools, can be installed with a press fitted with flat dies. Further, they do not discolor, deform or buckle the metal in which they are mounted. And they do not project from the opposite side of the plate, a design advantage where minimum clearances are involved.

Push-out and torque-out values of SPS Swage Nuts are the highest available for fasteners of this type. This insures proper torquing of screws and increases reliability under working loads and vibration.

SPS Swage Nuts can be used in metal with a hardness up to approximately Rockwell C25. This is an advantage over comparable fasteners, because it includes steel, as well as the usual alloys of copper, Monel or aluminum. Swage nuts are available in sizes #2 through ½ in. (2B threads), with shank lengths for plate from .020 to .250 in. thick. For complete information, write for new Swage Nut bulletin (Form 2447) and samples. Aircraft/Missiles Division, STANDARD PRESSED STEEL Co., Jenkintown 18, Pa.

**Step 1.** Enlarged cross-section shows #8-32 SPS Swage Nut inserted in hole ready for swaging into plate. Ordinary hydraulic or pneumatic presses—even portable rivet setters—serve satisfactorily as installation equipment.

**Step 2.** Pressure displaces metal around edge of hole, forcing it into retaining groove. Swage ring knurls increase resistance to torque-out, also provide relief for metal flow. Note smooth surface on bottom of plate.

## HIGH RELIABILITY

SPS research is continually developing fasteners with higher standards of predictable performance. By installing SPS high-reliability fasteners in your assemblies, you increase overall product reliability.

**For more information on the full meaning of reliability, write for a copy of the new SPS booklet "High Reliability."**

SPS **Jenkintown • Pennsylvania**

**Standard Pressed Steel Co.** • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co. • National Machine Products Co. • Nutt-Shel Co. • SFS Western • Standco Canada Ltd. • Unbrako Socket Screw Co., Ltd.

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DIMENSIONS IN INCHES

| FRACTION ± | TOLERANCES .X ± | .XX ± .03 | .XXX ± .010 | ANGLE ± |
|---|---|---|---|---|

LAYOUT See file 166-A

CUSTOMERS SEE DWG 33644

| | |
|---|---|
| DATE | 6/19/58 |
| DFTMN | JN |
| CHK | BJC |
| MATL | Spec. 104 |
| STRESS | Std |
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| PROD | [illegible] |
| APPD | 7/2/58 |

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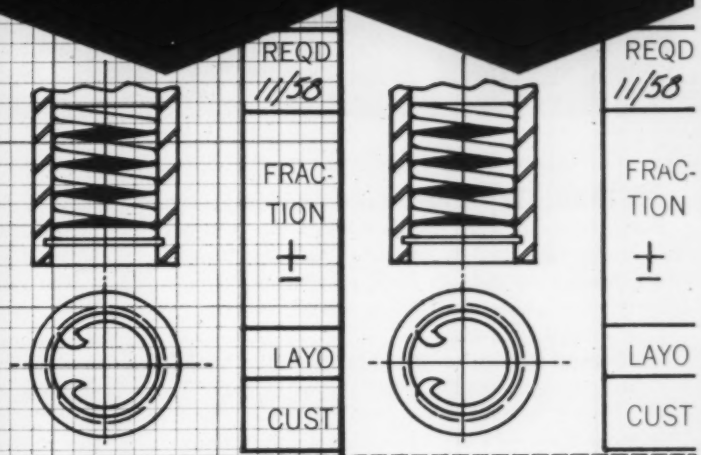


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**Formability**—In days of old, when knights were bold, they also were smart. When their very lives depended on a tool or a weapon, they made sure it was made from steel. It could be a great claymore, hefty enough to behead a horse; a bright suit of armor that would turn the Saracen's arrow; or an ornamental castle gate, strongly made to frustrate the assassin.

They wanted steel because it was strong. They could *use* it because it was formable. Truly, there is no economical metal in all the world that can approach steel's combination of strength and formability.

With the near-magic of heat treating, you can soften steel and form it, then harden it to make it strong, then temper it to make it tough. Or form it cold. Use bending, flanging, deep drawing, spinning, cold heading, die drawing, rolling, wiper forming, draw rolling, stretch forming or bumping. In fact, it's hard to imagine any forming operation that cannot be performed on steel.

Fortunately, there are hundreds of different kinds of steel; and they all act differently in the fabricating shop. Everything you do to steel alters its *forming* properties, and every forming operation alters its physical properties.

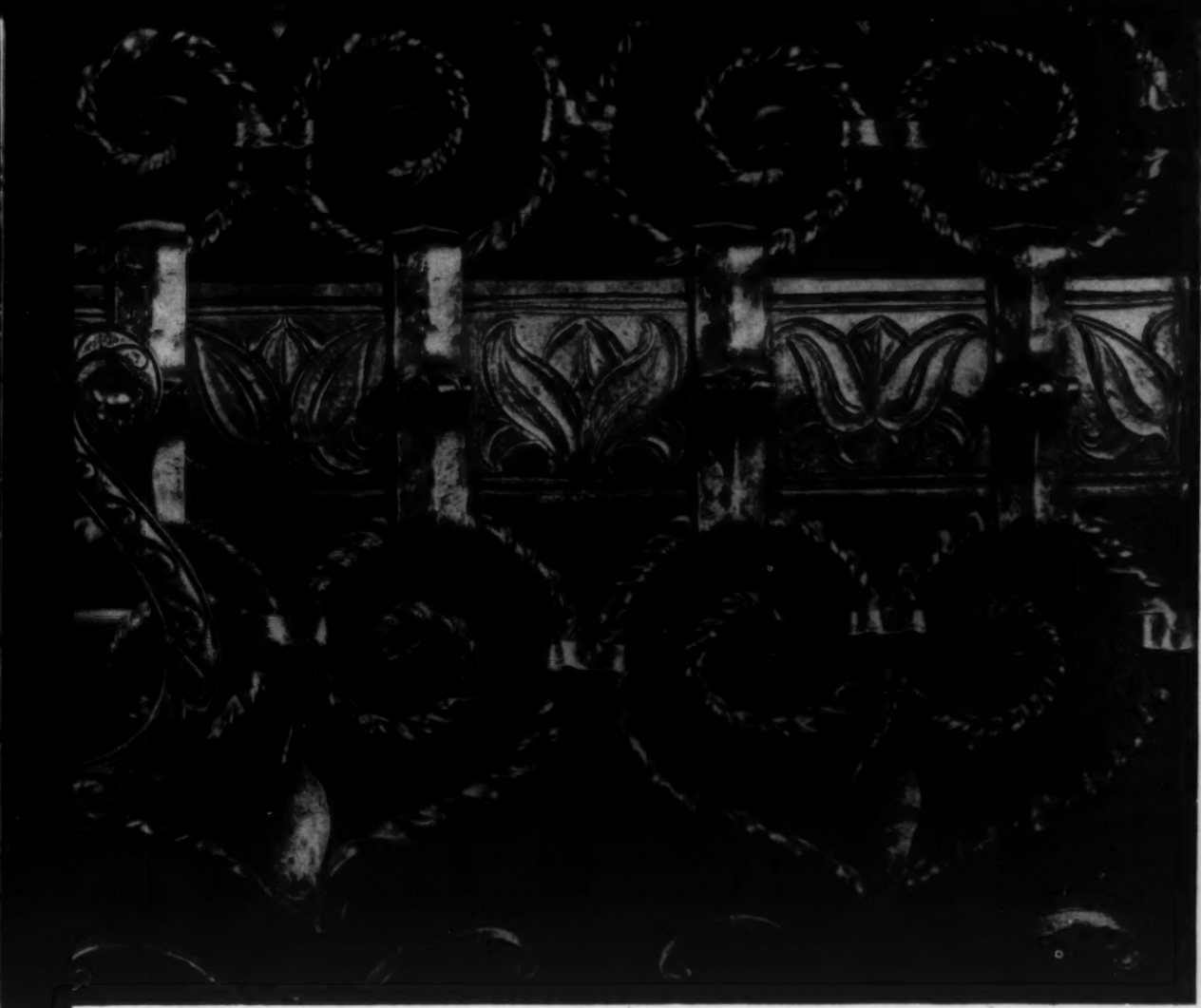
The aim of the product designer is to find a steel that can be properly formed, that has the right strength, toughness, corrosion resistance, weldability or other characteristics required . . . at the most favorable cost. If you have a design problem and the comptroller is looking over your shoulder, take hope from this idea: there is one "best" steel for any design application. You can be sure of finding it among the great family of USS Design Steels: Carbon, High Strength, Alloy and Stainless Steels.

If you need help in making your selection, ask a company that has produced well over a billion tons of steel, and has spent hundreds of millions of dollars to learn more about this most versatile of man's metals. Of course that means United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

United States Steel Corporation • American Steel & Wire • Columbia-Geneva Steel • National Tube
Tennessee Coal & Iron • United States Steel Supply • United States Steel Export Company

USS **United States Steel**

Please direct inquiries to advertiser, mentioning MACHINE DESIGN



# STEELS FOR PEOPLE

**Lower Left**—Problem: Build a power shovel dipper stick with greater strength and shock resistance. Solution: Bucyrus-Erie Company designed a tubular stick made from USS "T-1" Constructional Alloy Steel. Payoff: The "T-1" Steel plates were easily cold-formed into a tube and butt welded. The tubular design and stronger steel assured great strength and shock resistance, and easy fabrication.

**Lower Middle**—Problem: Produce strong, heat resistant, corrosion resistant jet engine rings—*economically*. Solution: Alloy Manufacturing Company carefully selected a grade of USS Stainless Steel. Payoff: The rings resist heat and corrosion and they are economically roll-formed because the Stainless Steel is formed on "carbon steel rated" equipment.

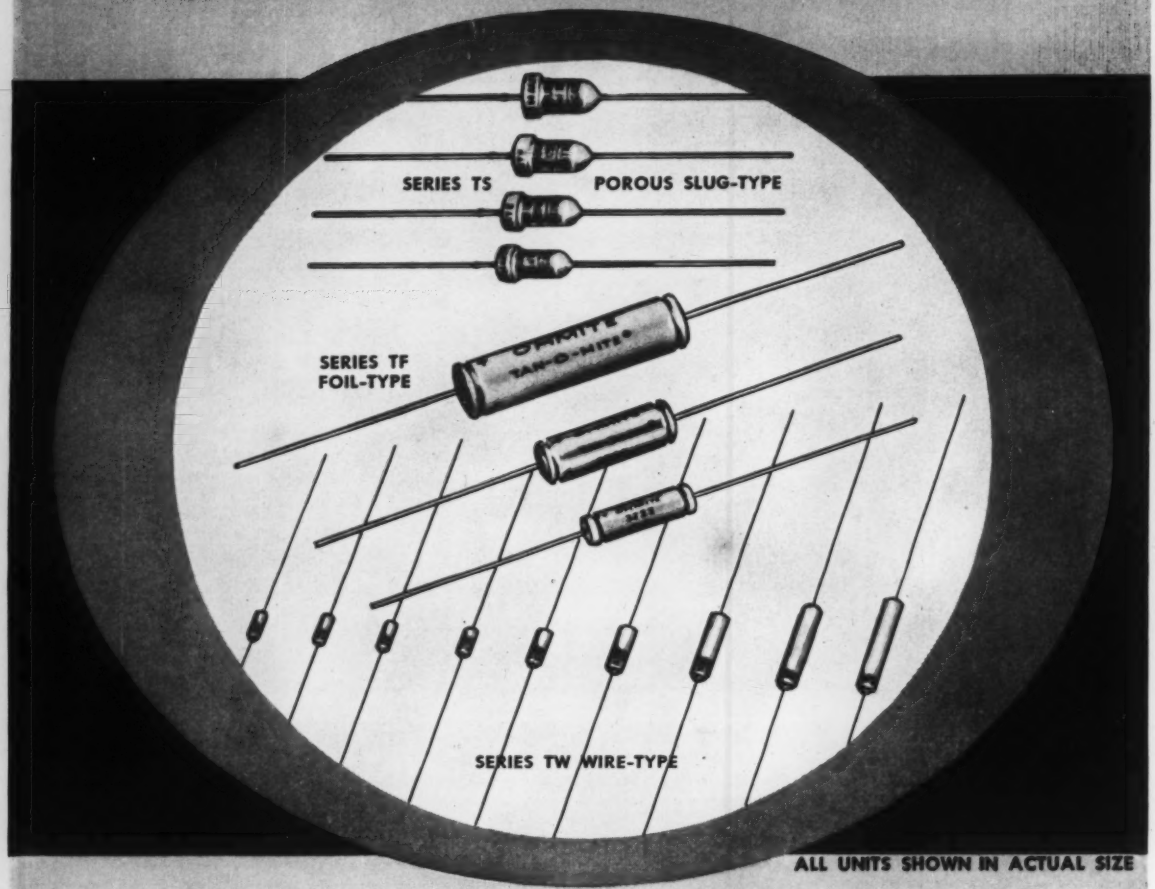
**Lower Right**—Problem: Design a pressure tank that is just as strong but lighter than conventional carbon steel tanks. Solution: Manufacturer selected USS MAN-TEN High Strength Steel. Payoff: MAN-TEN'S greater strength (50% higher yield point than carbon steel) permitted design of a thinner-walled tank that is 24% lighter. And because MAN-TEN is highly formable, the tank is economically produced by cold press forming of circular blanks into seamless shells, 29" in diameter and 24" deep.

*USS, "T-1" and Man-Ten are registered trademarks*

CHOOSE THE TYPE THAT BEST FITS YOUR APPLICATION FROM THE COMPLETE LINE OF QUALITY

# OHMITE®

## "TAN-O-MITE" TANTALUM CAPACITORS




ALL UNITS SHOWN IN ACTUAL SIZE

- Stability of Electrical Characteristics
- Long Shelf and Operating Life
- Excellent Performance Under Temperature Extremes (−55°C to + 85°C)

Ohmite offers you a complete line of quality tantalum capacitors including three types . . . all available from stock in reasonable quantities. **SERIES TS POROUS SLUG-TYPE TANTALUM CAPACITORS** employ a porous anode of sintered tantalum sealed into a fine silver case, externally uninsulated. Size "U" unit offers a range of 1.75 microfarads to 30 microfarads. Working voltages to 125 are available, depending upon capacity. These capacitors are polar units intended for d-c applications. BULLETIN 159.

**SERIES TF FOIL-TYPE** These capacitors are tantalum foil, electrolytic units for low-voltage, a-c and d-c applications. Three sizes now available; .25 to 140 mfd over-all capacitance range. Standard tolerance is ±20%. Working voltages up to 150. Polar and nonpolar units available. BULLETIN 152.

**SERIES TW WIRE-TYPE TANTALUM CAPACITORS** These Mylar® insulated, subminiature, wire-type units feature greater capacitance per unit volume, lower leakage current and power factor, and small capacitance drop at extremely low temperature as compared to other kinds of electrolytics. Ultrasmall for low-voltage, d-c, transistorized electronic equipment. Available in nine subminiature sizes; .01 to 80 mfd over-all capacitance range. Smallest size is .080 x .203 inch; largest is .134 x .812 inch. BULLETIN 148.

QUALITY Components **OHMITE® Manufacturing Company** 3618 Howard Street, Skokie, Illinois

RESISTORS RELAYS TAP SWITCHES RHEOSTATS TANTALUM CAPACITORS R. F. CHOKES VARIABLE TRANSFORMERS DIODES



Circle 473 on Page 19

## Designers who look to Nylon look to NATIONAL first

For fabricated parts—or for extruded strip, rod, tubing or special shapes—you'll find National a dependable primary source of Nylon. Costly molds and time delays may favor the delivery of 100% usable parts fabricated from National Nylon and timed to your production needs.

In many cases, fabricated parts from standard or special extruded shapes give you more design freedom at no greater unit cost. Buying from the source makes this possible. Before you "freeze" a molded design, talk with your National Sales Representative.

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THE DODGE STEEL Ladle

BUSINESS MAGAZINE EDITION

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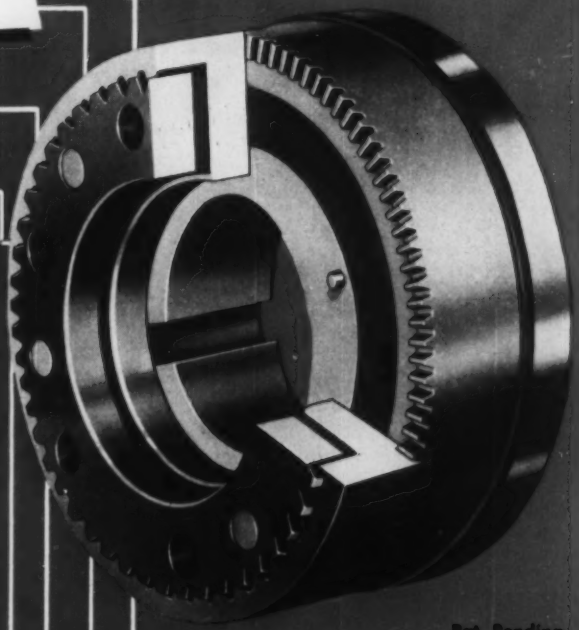
Circle 475 on Page 19A

Circle 476 on Page 19A

IDEA—
*for your power transmission file—*

# McCauley Electro-Magnetic Tooth Clutch



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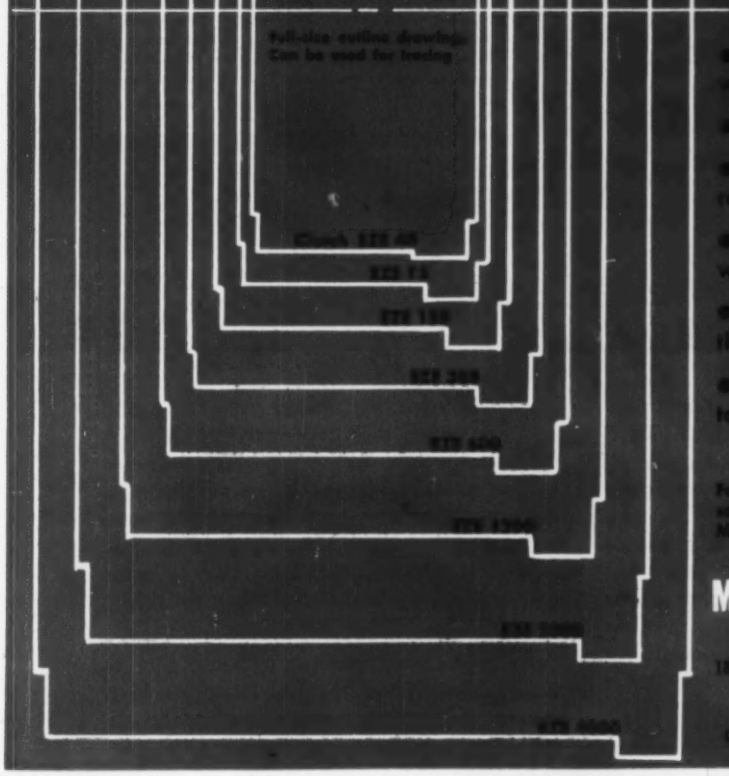


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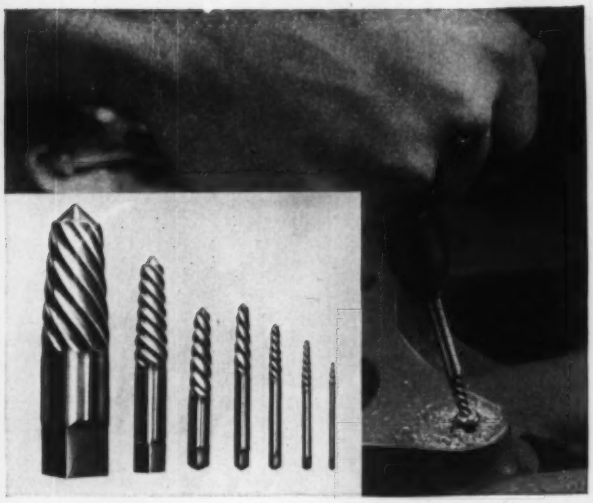

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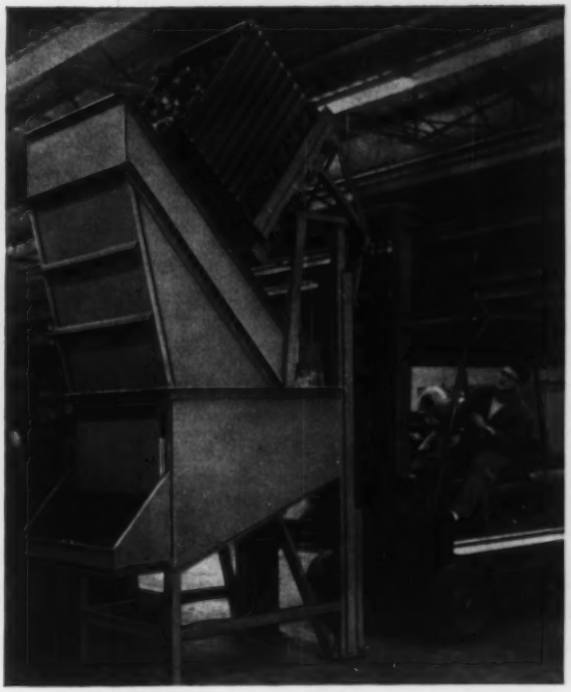

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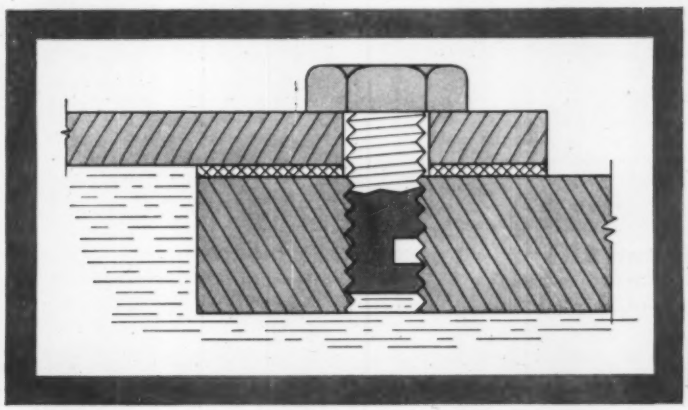

**LIQUID SEALING PERFORMANCE** is an added benefit of Republic Self-Locking Nylok® Bolts. As shown here, the nylon pellet in compression tends to expand and interrupt space between non-loadbearing surfaces of mating threads when bolt is wrenched tight. Fluid escape along helical thread path is blocked. Nylon pellet resists aging, moisture, and ordinary solvents to provide a long-lasting seal. Send coupon for information on all the benefits of Republic Nylok Fasteners.

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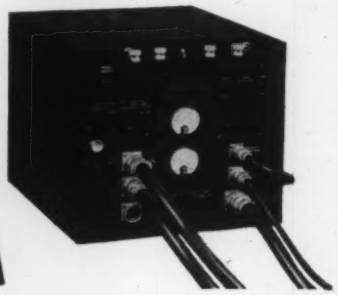
# connect with CANNON PLUGS

## APPLICATION

***Application of R and RK connectors on a recording oscillograph.***



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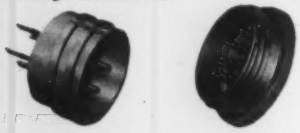

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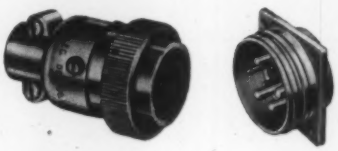

***SK-M7-21C***...Widely used on two leading makes of telephone recorded connector units known as "beepers" because of the signal required by law in such recordings.

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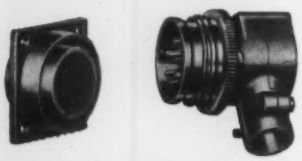

***RK*** plug and pin assemblies are equipped with an external threaded coupling nut which is the reverse of the standard K series. Note, RK will not mate with K's.

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See "K" Bulletin for Engineering Data.

***Please Refer to this Magazine or to Dept. 185.***

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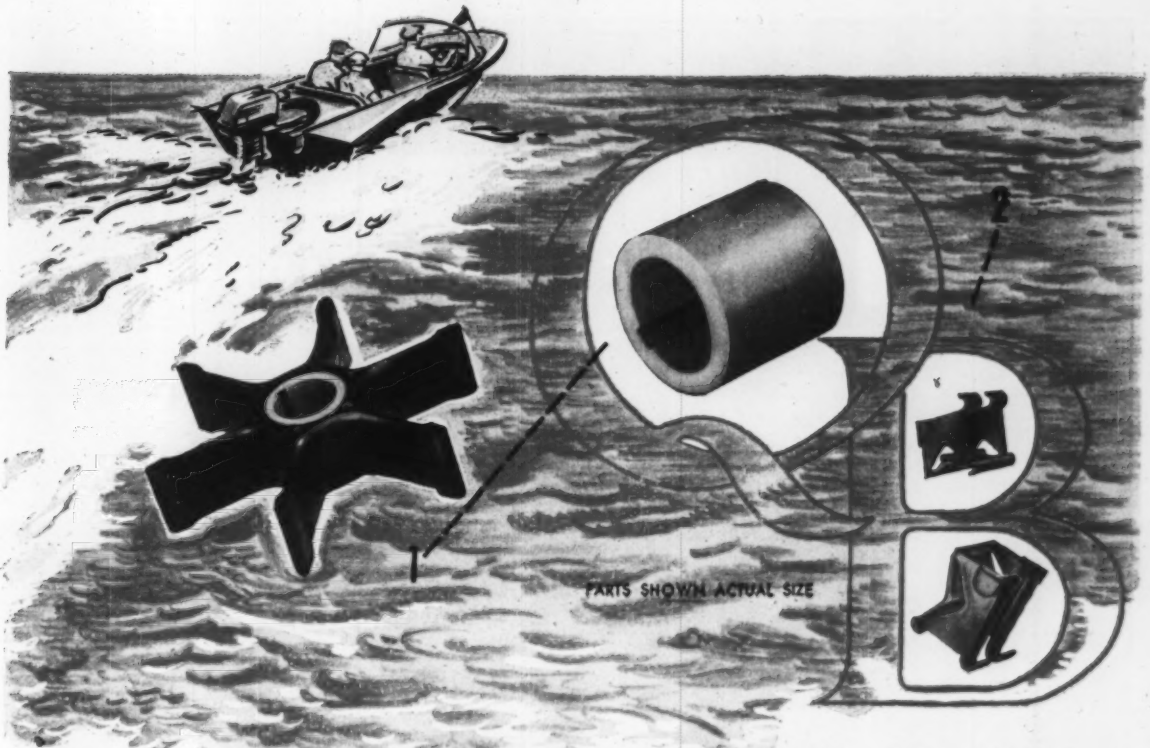


# These tough molded Thermoplastic Parts Laugh at Salt Water

## They're by Quinn-Berry, of course!

"WHERE THE UNUSUAL IS ROUTINE"

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1 At the left above is the Quinn-Berry molded nylon pump impeller insert used in Evinrude's 50 hp. Starflite motor. The dimensional stability of molded nylon affords tough resistance to thrust and shear stresses at all temperatures . . . and nylon is unaffected by salt water. It will not corrode.

2 Evinrude uses the molded nylon combination bearing and detent spring (above right) in the 10 hp. and 18 hp. motors to control the position of the choke. This Quinn-Berry molded part requires a minimum of lubrication, has excellent wearing characteristics and salt water will not corrode it.

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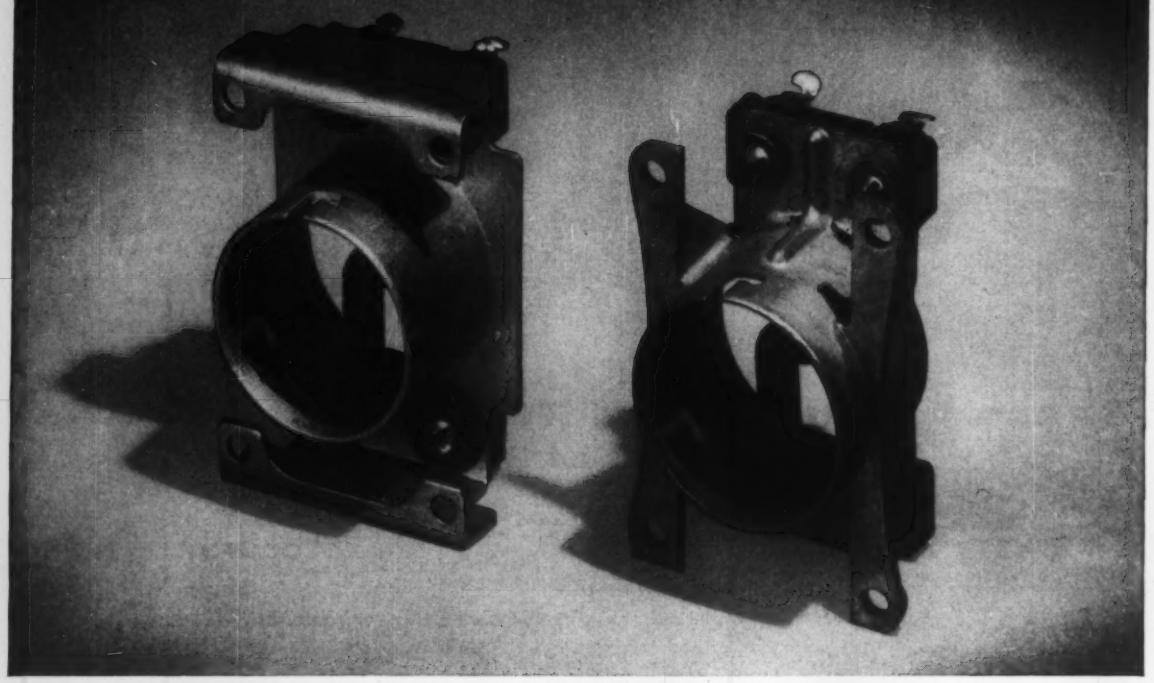
Circle 480 on Page 19

# ZINC DIE CASTINGS ARE BEST



Redesigning this vacuum tube base cut manufacturing costs by 50%.

The old base (shown at left) required seven operations from blanking the steel frame to staking the socket in position.

As a zinc die casting (shown at right), only one operation — punching the tube pin slot — was necessary. By die casting this part from zinc rather than from aluminum, the following *additional* advantages were achieved:

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MACHINE DESIGN
January 22, 1959

# Numbers

LORD KELVIN used to say that when you cannot express something with numbers, your knowledge is of a "meager and unsatisfactory kind." When the famous nineteenth-century scientist made this observation, engineering was still very much in the "mechanic arts" stage.

Then a new type emerged—the theoretical engineer. The theoretical engineer helped advance engineering design mightily, by virtue of his dedication to "numbers."

But mathematical theory has its limitations. So to the practical engineer fell the task of translating theory into working hardware. As a team, the practical and theoretical engineers have not always functioned in harmony. Foolish controversies used to rage over "theory" versus "practice."

Today the marriage of theory and practice is much closer to consummation than it was in Kelvin's day. Techniques of finding out whether you are actually getting what mathematics told you to expect have placed powerful tools in the hands of design engineers.

In his article beginning overleaf, Fran Fisher tells how dynamic measurement techniques can do just that. Thus, by being able to put more numbers on what they are doing, design engineers can acquire more complete understanding and knowledge of the things they are working with.

The result: Better design.

Colin Carmichael
EDITOR

# MEASUREMENT

SEPARATING cause from effect, measurements are often indispensable in trouble shooting a design. They show where to apply engineering effort in correcting the fault instead of treating the symptom.

Measurements open the door to the application of theoretical equations by eliminating assumptions. They also reveal the basic nature of the phenomenon so that it can be recognized.

Measurements shown on an oscilloscope accelerate experience by allowing the designer to observe variables while the mechanism is being subjected to various work loads. Also revealed are dynamic behavior characteristics which would not be shown by ordinary observations and tests.

## Measurement Techniques

This article deals with some of the measurement techniques that have proved useful in the design of small high-speed mechanisms. In general, dynamic measurements on these mechanisms are more difficult than on larger ones. Measurements on these mechanisms are made through a "pick-up" or transducer that converts the measurement of interest into an analogous electrical signal. The signal, which may represent force from strain gages, displacement from a precision potentiometer, velocity from a tachometer generator, etc., is then observed on an oscilloscope or recorded on some other output device, Fig. 1.

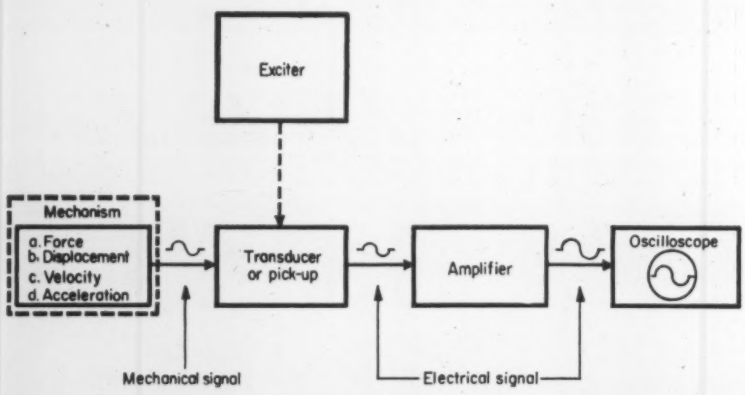



Fig. 1—Block diagram of instrumentation required for dynamic analysis of mechanism behavior

- *A machine or a mechanism fails to perform according to the designer's intent.*
- *What is the first step to take in solving this problem?*
- *Define the problem, of course.*
- *That's the job measurement can help do—without disturbing operation of the machine.*

# as a design tool

**By F. E. FISHER,** Manager, Mechanical Analysis Lab., International Business Machines Corp., Poughkeepsie, N. Y.

## Transducers—The Key

The transducer is the key to the measurement. Table 1 describes transducers which are useful on small high-speed mechanisms. Commercially available transducers shown in Table 1 require relatively simple circuits. Principles of operation, technical data, advantages and disadvantages serve to guide the designer in selecting a particular type of transducer for a specific problem.

In the illustrated schematics of the electrical circuits in Table 1, the output signal is measured on a voltmeter. In actual practice, an oscilloscope is usually used. It presents the information in a more useful form and has a fast time response compatible with phenomena generally of concern. For static measurements, a voltmeter would be satisfactory.

A calibration curve is shown to emphasize the need for calibration of any measuring system used. In addition, it points out the linearity limitations that some transducers have, such as the variable-reluctance type.

Accelerometers are not listed, but many good ones are commercially available. Of course acceleration can be obtained by differentiating velocity curves. Also, strain gages can be used and they indicate dynamic force which is, of course, directly proportional to acceleration.

## Practical Applications

It may appear to those design engineers who have not been involved in electrical instrumentation that the application of these transducers is difficult and practical only in isolated cases. This isn't true, fortunately. The circuitry is simple to apply, with the possible exception of that for strain gages. They require a certain amount of know-how, but the proper technique can be learned with little effort. As for isolated applications, the converse is true. The power of these measurement tools is in their practicality, and the heretofore unavailable data they give to the engineer.

At the IBM Mechanical Analysis Laboratory the following mechanisms have been studied:

1. Card and tape punches
2. Relays, magnets, and solenoids
3. Magnetic tape-transport systems
4. Card feeds
5. Die punches
6. Clutches
7. Keyboards
8. Cam drives

The following list points out the important data yielded from measurements on these mechanisms.

1. Acceleration and deceleration times
2. Impact forces
3. Dynamic forces
4. Resonant frequency
5. Magnitude and duration of contact bounce
6. Speed-regulation values
7. Overshoot amplitude
8. Energy for various work cycles
9. Impulse at pick-up or latch-up
10. Momentum at pick-up or latch-up
11. Time of events
12. Slipping torques

## Theoretical Applications

With these results, it takes little imagination to see the potential for mathematical analysis. Impulse-momentum equations, stress calculations, spring-mass simulation of a linkage, force-acceleration equations, and others can be applied to optimize a

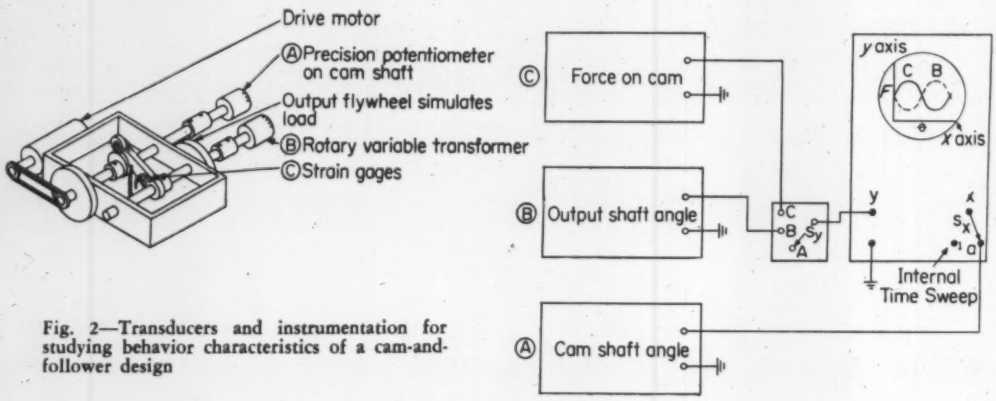



Fig. 2—Transducers and instrumentation for studying behavior characteristics of a cam-and-follower design

system observed with quantitative dynamic measurements.

The important contribution that measurements make to the practical application of theory is often overlooked. Theory usually means expressing some physical phenomenon with equations. The economics of being able to describe a real system with a mathematical model is obvious. The usual question is, "Does the mathematical model truly correspond to the real system?" Measurements often quantitatively establish this correspondence. Measurements define and show what the real system is.

## Cam-Mechanism Example

A typical setup for measuring force on a cam, displacement of an output shaft, and angular position of a cam shaft is shown in Fig. 2. The outputs of the various transducers are displayed on an oscilloscope.

**Cam Shaft:** Initially, the mechanism is not running. With the switches $S_y$ at off and $S_x$ at $A$, Fig. 2, the cam shaft is rotated. The potentiometer shaft, attached to the cam shaft, rotates causing a corresponding change in output voltage. Since this voltage goes to the $x$-axis of the scope, the electron beam on the face of the scope moves horizontally corresponding to the transducer voltage. By proper adjustment, the scope can be calibrated so that the left origin corresponds to 0 deg of shaft angle and each inch of beam travel to the right corresponds to 90 deg of cam angle.

If the beam were 3 in. to the right of the origin, the cam angle would be 270 deg. For this "pot" the beam cannot be seen from 355 to 360 deg because of a 5-deg void in the "pot's" resistance element where the end terminals are separated, Table 1. At 360 deg plus, the beam would reappear at the left-hand origin. If the mechanism is turned on at this time, a horizontal line would start sweeping across the scope, one sweep from 0 to 355 deg per revolution of the cam shaft. The beam would be mechanically synchronized with the cam shaft.

**Cam Force:** Examine the force pick-up by throwing the switch $S_y$ to position $C$. The output voltage from the strain gages establishes the $y$ position of the electron beam. A good way to introduce a force at the cam is to apply a torque at the output flywheel such that a compressive reaction force is set up between the cam and the follower. If this is done, the resulting bending strains in the cam follower cause a voltage output from the gages of $C$ that will drive the electron beam in a vertical direction.

To calibrate the scope, the output shaft must be clamped so the follower roller will clear the cam and apply known loads at the cam follower. The follower springs must be removed. The sensitivity of the scope can be adjusted so an upward force of 10 lb at the roller causes a 1-in. vertical deflection of the beam upward. The $y$ position on the scope face now indicates the force acting at the cam. A plus 1-in. deflection equals 10 lb of compressive force.

**Output-Shaft Displacement:** If the $S_y$ switch is thrown to $B$, it can be demonstrated by lifting the cam follower that the $y$ position of the beam corresponds to output shaft angle. Since this transducer is of the transformer type, the output will be an alternating voltage and the beam will be oscillating up and down in a vertical line. Shaft position will correspond to the maximum vertical displacement of the beam where its image is the brightest.

**Mechanism Running:** If the drive motor is turned on, the beam would begin plotting output-shaft angle versus cam-shaft angle, Fig. 3*a*. Actually, the curve in Fig. 3*a* is output-shaft angle versus time because the switch at $S_x$ was set at 1 for this particular picture. The time-sweep period was adjusted to correspond to 1 revolution of the cam shaft so switching $S_x$ from 1 to $A$ would not change the picture,

providing the time sweep is synchronized to start when the cam shaft is at 0 deg. When a "pot" is used to drive the $x$ axis, as has been described for the switch set at $A$, there are no time-sweep synchronization problems. Fig. 3*b* represents force versus time with switches $S_y$ at $C$ and $S_x$ at 1.

**Velocity:** In Fig. 3c appears the curve of velocity versus time. No velocity pick-up is indicated in the mechanism shown in Fig. 2. However, if the rotary variable transformer is excited by a dc voltage, instead of a sinusoidal voltage as is done normally, the output of the rotary variable transformer is proportional to velocity. This has been done to produce the velocity versus time trace. See comments about rotary variable transformers in Table 1.

**Results:** In Fig. 4 are dual-beam oscilloscope traces representing the simultaneous display of force and velocity. Force and velocity are good choices for detecting bounce between the cam and its follower; hence it is useful to find the maximum speed at which this system can be driven. The plot in Fig. 4*a* was taken with the mechanism operating at the maximum speed before bounce. Fig. 4*b* represents a slight increase in speed which has produced bounce. Note the sudden velocity changes (acceleration) and the corresponding forces. As shown, two modes of vibration are indicated by the force curve. In Fig. 4*a* the phase difference between force and velocity can be seen.

It is reassuring to see the laws of mechanics in agreement with observed data, i.e., the velocity curve is the derivative of the force curve. The quantitative information from these few measurements illustrates the detailed analysis that can be made of a mechanism.

ACKNOWLEDGMENT

This article is based on a paper presented at the Fifth Conference on Mechanisms, cosponsored by Purdue University and MACHINE DESIGN, October 13-14, 1958.

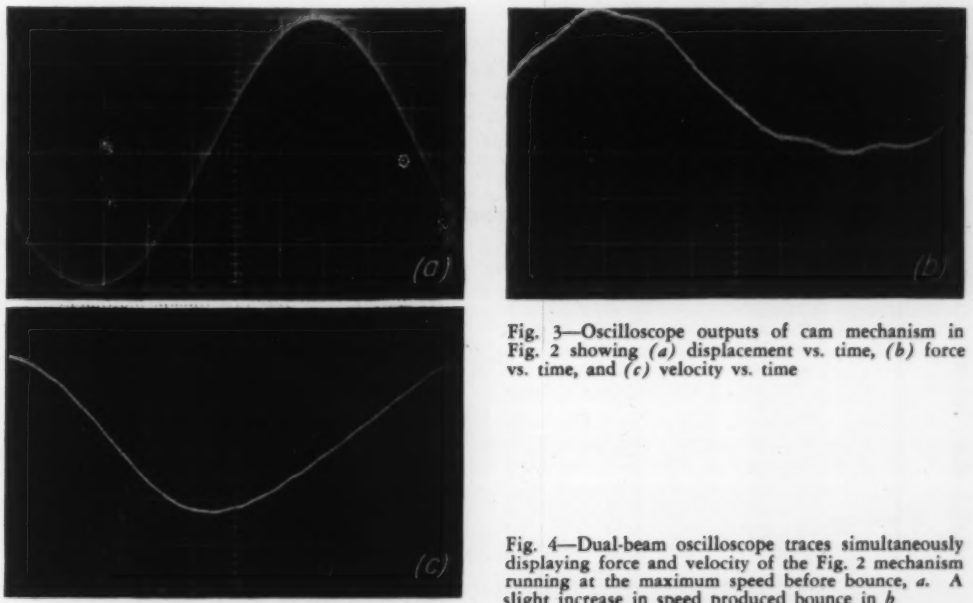



Fig. 3—Oscilloscope outputs of cam mechanism in Fig. 2 showing *(a)* displacement vs. time, *(b)* force vs. time, and *(c)* velocity vs. time

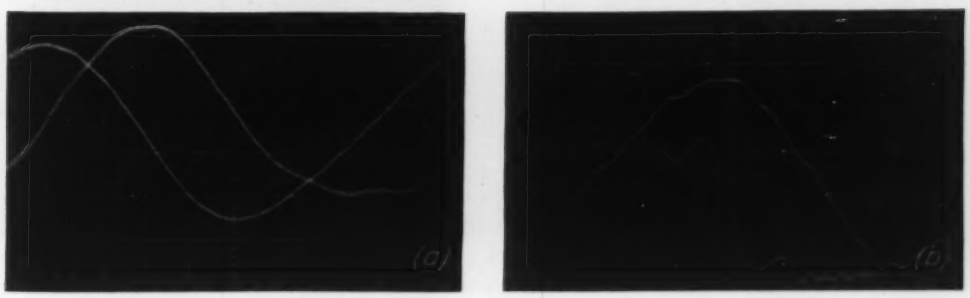



Fig. 4—Dual-beam oscilloscope traces simultaneously displaying force and velocity of the Fig. 2 mechanism running at the maximum speed before bounce, *a*. A slight increase in speed produced bounce in *b*

# Table 1—Typical Electromechanical Transducers

## Displacement Transducers

### A. Angular Wire-Wound Resistance Potentiometer

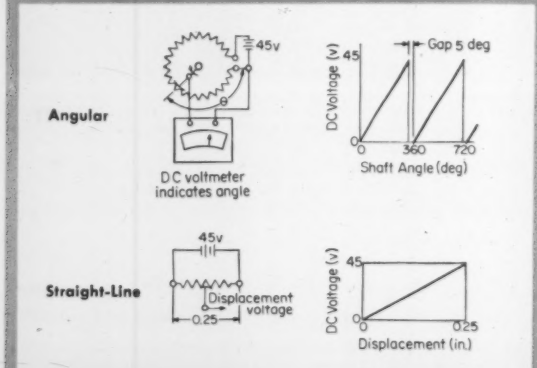
1. **Description**
   Changes in angular position cause changes in resistance. A highly uniform resistance element is formed in a circle. A slider or brush rotating about the center contacts the wire-wound resistance element. The rotating slider is driven by a shaft.
2. **Technical Data**
   a. Range: Continuous rotation 0 to 355 deg.
   b. Resolution: Approximately 0.6 deg average.
   c. Linearity: 0.1 to 2 per cent.
   d. Inertia: 3 to 14 gm $cm^2$.
   e. Life: $10^6$ cycles.
   f. Order of signal level: 10 v.
3. **Advantages**
   a. Simple.
   b. Few accessories needed.
   c. High signal level.
   d. Dc output.
   e. Rugged.
   f. Easy to mount.
4. **Disadvantages**
   a. Resolution limited by wire size.
   b. Limited life.
5. **Typical Manufacturer**
   Helipot Corp., South Pasadena, Calif.

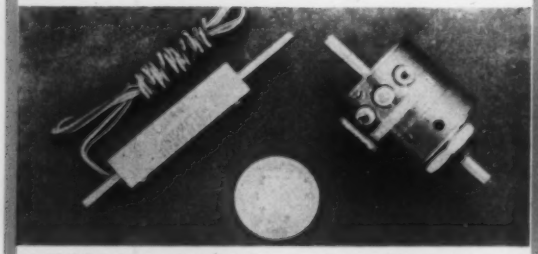
### B. Straight-Line Wire-Wound Resistance Potentiometer

1. **Description**
   Same principle of operation as for angular except the slider moves linearly.
2. **Technical Data**
   a. Range: 0.5 to 6.5 in.
   b. Resolution: 0.001 to 0.0045 in.
   c. Linearity: 1 per cent.
   d. Life: $10^6$ cycles.
   e. Order of signal level: 10 v.
3. **Advantages and Disadvantages**
   a. Same as for angular potentiometer.
4. **Typical Manufacturer**
   Bourns Laboratory, Riverside, Calif.

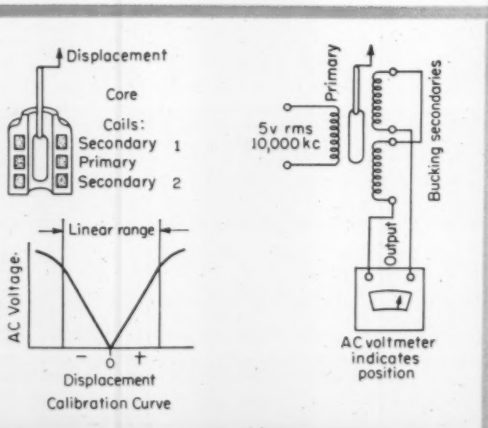
### C. Linear-Differential Transformer

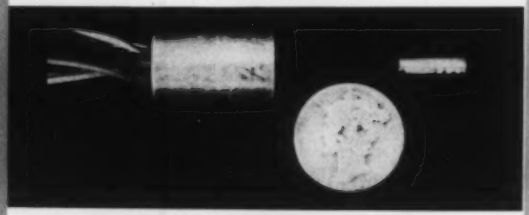
1. **Description**
   Displacement of a soft-iron core varies the reluctance coupling between a primary and a pair of secondary coils. The secondaries are connected bucking. When the coupling between the primary and the pair of secondaries is equal, there is no output and the core is in its null position. Movement in either direction will improve the coupling with the secondary on that side. The favored secondary overpowers the other secondary giving an output proportional to displacement within a limited range, i.e., a linear differential output. The primary is excited with a fixed-frequency sine wave.
2. **Technical Data**
   a. Range: 0—0.005 to 0—1 in. standard.
   b. Resolution: 0.1 per cent of range.
   c. Linearity: ±0.5 per cent.



**Wire-Wound Resistance Potentiometers**



**Linear-Differential Transformer**

d. Sensitivity: 1 to 4 mv per 0.001 in. per v input.
e. Inertia: 0.1 to 30 grams core weight.
f. Life: Infinite.

3. **Advantages**
   a. High sensitivity.
   b. Long life.
   c. Simple electrical circuit.
   d. Low drag.
4. **Disadvantages**
   a. Requires oscillator.
   b. Adds some inertia.
   c. Some mounting problems.
   d. Ac output.
5. **Typical Manufacturer**
   Schaevitz Engineering, Clifton, N. J.

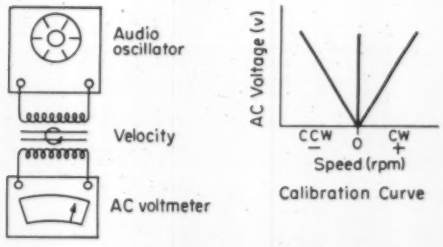
## Velocity Transducers

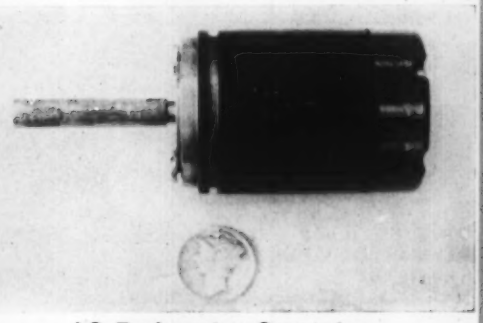
### A. AC Tachometer Generator

1. **Description**
   A rotating drag cup cuts an excited field and induces a field of its own proportional to its rotating velocity. This field then excites the secondary output coils providing the velocity signal. This is the principle of operation of most ac tachometer generators.
2. **Technical Data**
   a. Sensitivity: 3.2 v rms per 1000 rpm.
   b. Inertia: 2.1 gm $cm^2$.
   c. Exciting Voltage: 115 v, 400 cps.
   d. Linearity: ±0.2 per cent up to 5400 rpm.
3. **Advantages**
   a. Simple.
   b. Rugged.
   c. Long life.
   d. High signal level.
4. **Disadvantages**
   a. Output is ac.
   b. Response is limited to the exciting voltage frequency; however, excitation can be 2kc for better time resolution.
5. **Typical Manufacturer**
   Kearfott Co. Inc., Clifton, N. J.

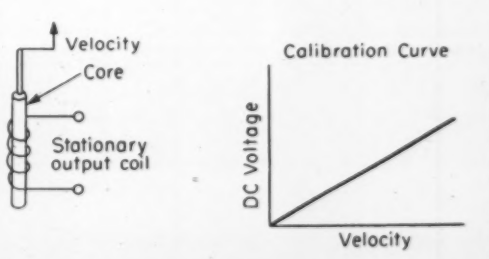
### B. Straight-Line Velocity Pick-Up

1. **Description**
   A permanent-magnet core moved concentrically in a coil inducing a voltage proportional to velocity.
2. **Technical Data**
   a. Displacement Range: 0—0.5 to 0—9 in.
   b. Sensitivity: 120 to 650 mv per in/sec.
   c. Inertia: 0.0007 lb to 0.15 lb.
   d. Life: Infinite.
3. **Advantages**
   a. Simple.
   b. High sensitivity.
   c. Can differentiate signal for acceleration and integrate for displacement.
   d. Long life.
4. **Disadvantages**
   a. Difficult to calibrate.
5. **Typical Manufacturer**
   Sanborn Co., Waltham, Mass.



**AC Tachometer Generator**



**Straight-Line Velocity Pick-Up**

# Table 1 cont.–Typical Electromechanical Transducers

## Displacement and Velocity Transducers

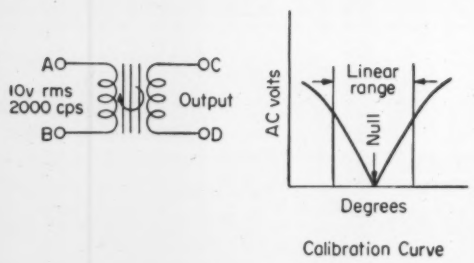
### A. Rotary Variable Transformer

1. Description
   The same principle of varying the reluctance coupling as described for the linear-differential transformer applies. The rotor provides the variable reluctance coupling.
   The rotary variable transformer may be used as a velocity pick-up by exciting the primary coils at terminals A and B with a battery. The rotor then behaves as a permanent magnet. The linearity range is limited and must be determined by calibration.
2. Technical Data
   a. Range: ±10 to ±40 deg.
   b. Resolution: Continuous; however, the time scale is limited iin resolution by the frequency of the exciting voltage.
   c. Linearity: 1 per cent full range.
   d. Life: Infinite.
   e. Sensitivity: About 3 v/deg.
3. Advantages and Disadvantages
   a. About the same as for the linear-differential transformer.
4. Typical Manufacturers
   a. Doelcam Co., Boston, Mass.
   b. Schaevitz Engineering, Clifton, N. J.

## Force (Acceleration) Transducers

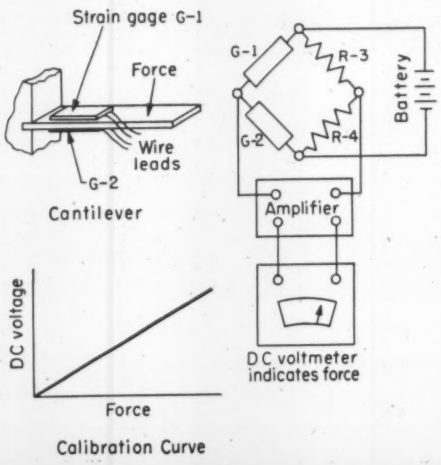
### A. Strain Gages

1. Description
   Changes in wire length cause changes in resistance. A wire grid properly insulated and cemented to a part that is subjected to a load will change length producing a voltage signal proportional to the load. Technical information on strain-gage techniques is available from the Society for Experimental Stress Analysis, Cambridge, Mass.
2. Technical Data
   a. Order of signal level: Millivolts.
   b. Resolution: Continuous.
   c. Range: Practically unlimited.
   d. Linearity: 0.1 per cent attainable.
3. Advantages
   a. Small.
   b. Does not load system.
   c. Adaptable to wide range of applications.
4. Disadvantages
   a. Amplifier usually necessary.
   b. Small signal level creates noise problems.
   c. Requires good technique.
5. Typical Manufacturer
   Baldwin-Lima-Hamilton, Philadelphia, Pa.

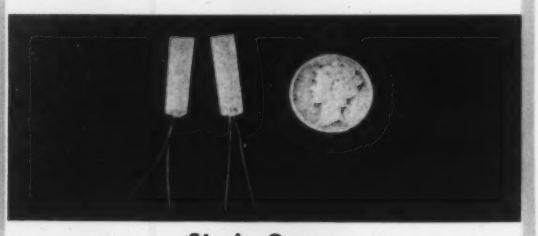



Calibration Curve

**Rotary Variable Transformer**



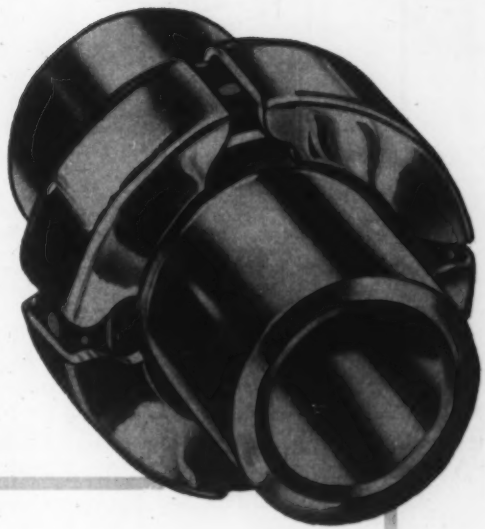

Calibration Curve

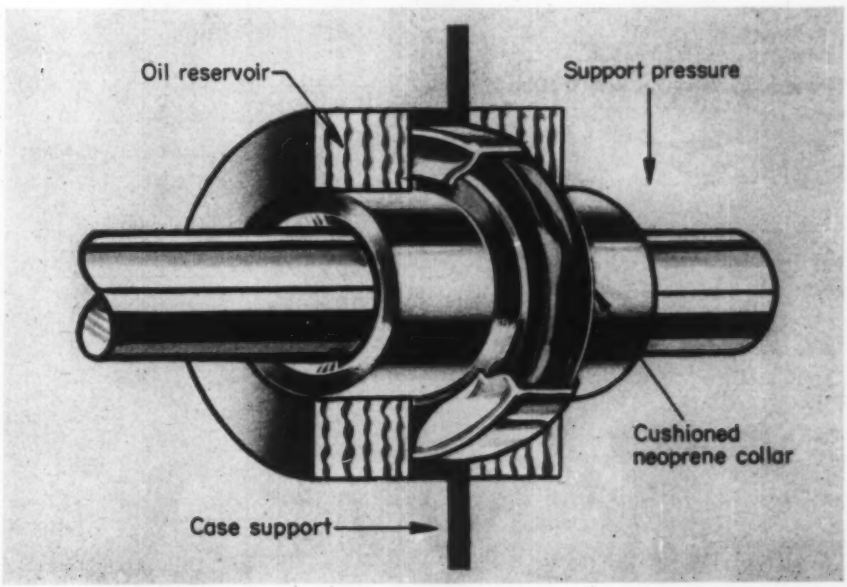


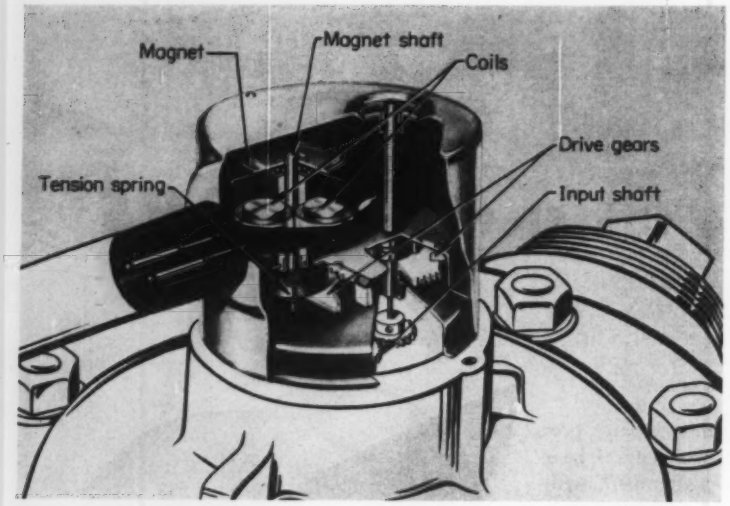
**Strain Gages**

# scanning the field for *ideas*

**Bearing alignment collar** permits support pressure to be applied at center instead of at end of bearing and adjusts axial position to true alignment without use of springs. In a bearing design developed by Universal Electric Co. for application on fhp motors, a neoprene collar is fitted around the outside surface of the bearing. Metal clips contain the collar and permit free sliding movement along the bearing support surface. Support pressure is transmitted from the support case, through the clips and collar, to the center of the bearing. The neoprene collar accommodates manufacturing tolerances and expands or contracts within the clips to produce a form fit between bearing and bearing support surfaces.

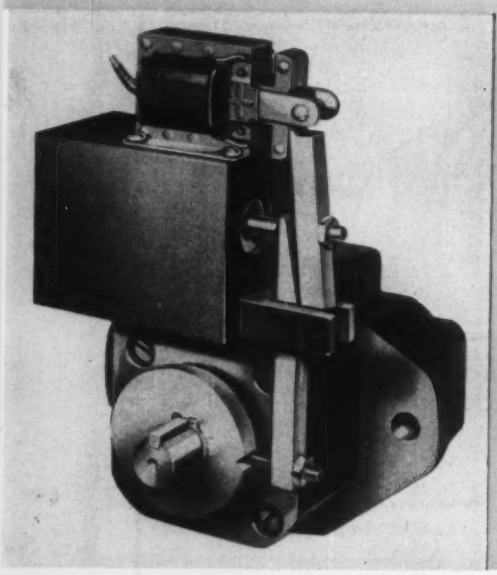


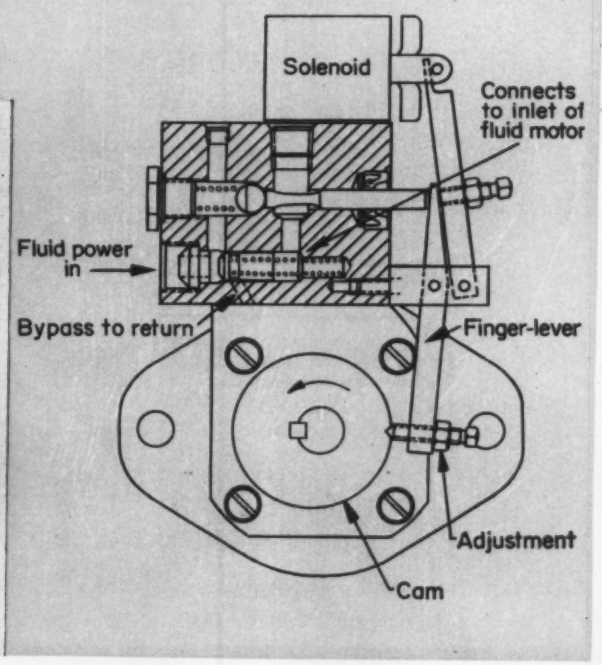


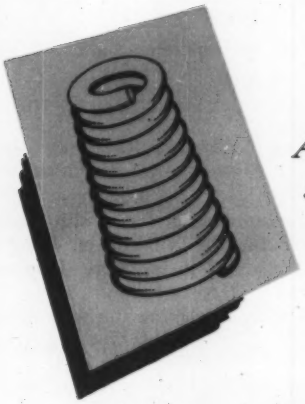



**Quick-escape magnet** generates low-voltage electrical pulse for precision counting. Rotary motion of input shaft turns gear with separated tooth sections for intermittent engagement with a gear that drives a ceramic magnet against a torsion spring. The magnet rotates over coils with built-in polarity. When the gears run out of mesh, the magnet is returned to neutral position by the torsion spring. Quick escape of magnet over coils generates an electrical impulse. The principle is used in the Read-o-Matic register for liquid metering and machine-cycle counting applications.

**Full-cycle speed control** of fluid motor is provided by cam and compensating-valve linkage. In a one-revolution motor unit designed by John S. Barnes Corp., an adjustable finger-lever arrangement connects a cam and hydraulic valve. Momentary actuation of a solenoid advances the valve stem, lifting ball check off its seat and allowing flow of oil past ball to give initial motion to motor and cam. Cam action, through finger-lever arrangement, advances or retards valve stem to vary oil flow and motor speed over full range of rotation.







*A helical spring around two coaxial shafts makes a good one-way clutch. It drives in one direction, drags in the other.*

*But this arrangement provides another unique possibility. The drag can be exploited in a controlled manner for*

# SLIP CLUTCHES AND BRAKES

**By JOSEPH KAPLAN**
Senior Project Engineer
Fairchild Camera and Instrument Corp.
Syosset, Long Island, N. Y.

INHERENT CAPABILITIES of spring clutches are their ability to transmit large torques in one direction of rotation, and to override when the direction is reversed. Since torque transmission is the property most often used, drag in the overriding direction is usually considered a factor simply to be tolerated. However, spring clutch drag has certain aspects quite desirable for such mechanisms as brakes and slip clutches. Advantages in these applications include: Constant drag values independent of lubrication, reliable operation even at extreme temperatures, and slip torques which can be designed to be equal or different in the two directions of rotation.

**Override Drag Torque:** As derived in an earlier article,* the override drag torque of a spring clutch is

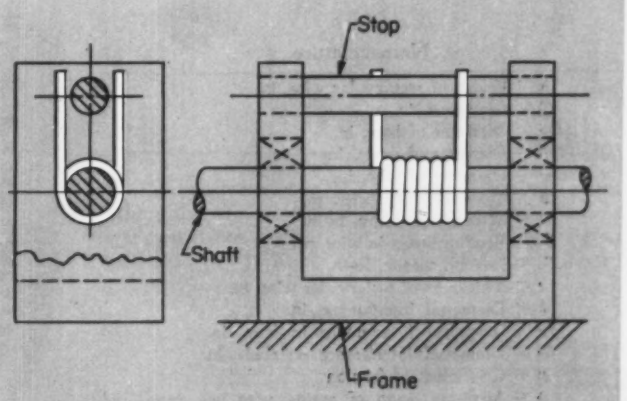
$$T_s = M(e^{-\mu\theta} - 1) \qquad (1)$$

Observe that $e^{-\mu\theta}$ decreases rapidly as the angle

*J. Kaplan and D. Marshall—"Spring Clutches," MACHINE DESIGN, Vol. 28, No. 8, April 19, 1956, pp. 107-111.

**Fig. 1—Constant-torque spring brake**

When the shaft is rotated, one of the spring ends contacts the stop and causes the spring to slip relative to the shaft. Rotation of the shaft in the opposite direction causes the other spring end to contact the stop and provide slip action. The drag torque produced by this design is the same for both directions of rotation, and is equal to the interference moment between the shaft and the spring.



of wrap of the spring increases. For the number of coils used ordinarily for clutches, $e^{-\mu\phi}$ approaches zero. Therefore, Equation 1 can be simplified for practical purposes to

$$T_\mu = M \qquad (1a)$$

Equation 1*a* states that the override drag of the spring clutch equals the interference moment of the spring and shaft combination. Also note that, while the coefficient of friction between the shaft and spring aids in generating the drag torque, the ultimate torque is limited only by the interference moment.

Since the modulus of elasticity of spring wire changes very little with variations in environmental temperature, the interference moment can be expected to remain constant over a wide range of temperatures. Consequently, slip clutches can provide reliably the same braking or slipping torques at room temperatures and extreme environmental temperatures. Similarly, variations in lubricating conditions do not change the drag torque, nor is starting drag different from dynamic drag. Other advantages, not quite as obvious from Equations 1 and 1*a*, are: Design simplicity, compactness of size, and ease of designing-in different drag torques for the two directions of rotation.

Representative models designed to provide drag are shown in Fig. 1 and 2.

**Design Equations:** The interference moment of a spring, assembled on a shaft, is the same as the moment it would have as a torsion spring wound to the same dimensions. Accordingly, equations which are valid for torsion springs can also be used to calculate interference moment. For convenience, diametral interference is substituted for the angular-deflection parameter normally used in torsion-spring calculations. Diametral interference is a more significant parameter in spring-clutch design because it represents the diametral expansion or contraction of the spring assembled on a shaft or in a bore.

The interference moment for several commonly used spring wire cross sections are: For round wire,

$$M = \frac{\pi E D_W^4 \delta}{32 D_D^2} \qquad (2)$$

## Nomenclature

$b$ = Width of rectangular wire, in.
$C$ = Clearance, in.
$D_B$ = Diameter of bore, in.
$D_D$ = Diameter of drum, in.
$D_W$ = Diameter of wire, in.
$E$ = Modulus of elasticity, psi
$M$ = Moment of spring, lb-in.
$S_b$ = Bending stress in wire, psi
$T_\mu$ = Friction torque, lb-in.
$t$ = Thickness of rectangular wire, in.
$\delta$ = Diametral interference, in.
$\delta_B$ = Diametral interference in bore, in.
$\delta_S$ = Diametral interference on shaft, in.
$\mu$ = Coefficient of friction
$\phi$ = Angle of wrap of spring wire per drum, rad

For rectangular wire,

$$M = \frac{E b t^3 \delta}{6 D_D^2} \qquad (3)$$

For square wire,

$$M = \frac{E t^4 \delta}{6 D_D^2} \qquad (4)$$

**Example:** Design requirements for a slip clutch are: Drag in one direction, $T_\mu' = 0.5$ lb-in. Drag in reverse direction, $T_\mu'' = 0.2$ lb-in. Bore diameter, $D_B = 0.5$ in.

Using round steel wire, determine the wire diameter, $D_W$, on the basis of 150,000 psi working stress. Also find the diametral interference for each direction of rotation, and the dimensions of the spring and shaft.

1. Wire Diameter: The major stress in the wire of a slip clutch or brake is due to the bending moment. The wire diameter is found with the aid of the widely used spring equation,

$$D_W = \sqrt[3]{\frac{32M}{\pi S_b}} = \sqrt[3]{\frac{32(0.5)}{\pi(150{,}000)}} = 0.033 \text{ in.}$$

2. Shaft Diameter: The bore diameter minus twice the wire diameter equals the shaft diameter. Allow an additional 0.010 in. for shaft misalignment and clearance, then shaft diameter is

$$D_D = D_B - 2D_W - C = 0.500 - 2(0.033) - 0.010 = 0.424 \text{ in.}$$

3. Diametral Interference: In the bore, substitutions in Equation 2 yield

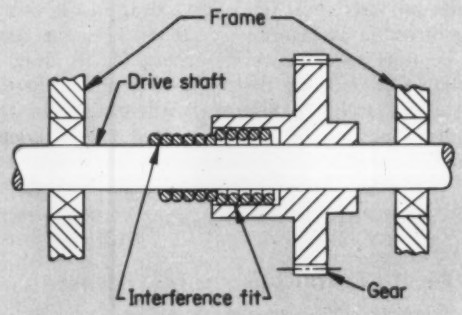



**Fig. 2—Bidirectional slip clutch**

**A two-diameter spring can provide different slip torques in the two directions of shaft rotation. One part of the spring fits tightly in the bore of the housing, and the other part is tightly wrapped around the shaft. When the shaft is rotated in one direction, relative to the housing, the spring grips the shaft tightly and slips in the bore. When rotation is reversed, the spring clings to the bore and slips on the shaft. In both cases, drag torque is the interference moment between relatively slipping members.**

$$\delta_B = \frac{32 D_B^2 T_\mu'}{\pi E D_W^4} = \frac{32(0.5)^2(0.5)}{\pi 30(10)^6(0.033)^4} = 0.036 \text{ in.}$$

On the shaft, substitutions in Equation 2 yield

$$\delta_S = \frac{32 D_D^2 T_\mu''}{\pi E D_W^4} = \frac{32(0.424)^2(0.2)}{\pi 30(10)^6(0.033)^4} = 0.011 \text{ in.}$$

4. SPRING DIMENSIONS: The outside diameter of coils wound in the bore is

$$0.500 + 0.036 = 0.536 \text{ in.}$$

The inside diameter of coils wound on the shaft is

$$0.424 - 0.011 = 0.413 \text{ in.}$$

Six coils in interference with each of the two elements should yield stable drag torques.

**Wear Characteristics:** Wear of the spring clutch is affected by the same factors present in most friction devices. These include pressure, lubrication, slip velocity, and materials. Of these factors, only pressure and the distribution of pressure along the spring are different than in most friction elements. When there is no relative motion in the clutch, the gripping force, per unit length of wire, is proportional to the interference moment. When slip occurs in the clutch, the gripping force is proportional to $Me^{-\mu\phi}$. At the free end of the spring, $\phi = 0$, and the gripping force is maximum. The gripping force diminishes to about $\frac{1}{3}$ maximum value for an angle of wrap of one coil having $\mu = 0.2$, and to about 1/10 maximum value for two coils also having $\mu = 0.2$. Since wear is a function of pressure, the area near the free end of the spring receives a great deal of wear when excessive drag is applied.

To obtain uniform distribution of gripping force over the length of the spring, one effective method utilizes a gradient of an increasing interference moment from the free end to the bridging coil. Two such designs are shown in Fig. 3.

Uniform distribution of the spring gripping force during slip eliminates severe localized wear. Wear can also be reduced by lubricating the slip surface of the clutch. Lubrication tends to reduce the coefficient of friction and consequently spreads the torque build-up to a larger number of coils.

One more important factor which affects the gripping force is the diameter of the shaft. For a given slip-torque capacity, the gripping force is inversely proportional to the square of the diameter of the shaft. Although slip velocity of the clutch increases linearly with shaft diameter, the net effect of a larger diameter is to reduce wear.

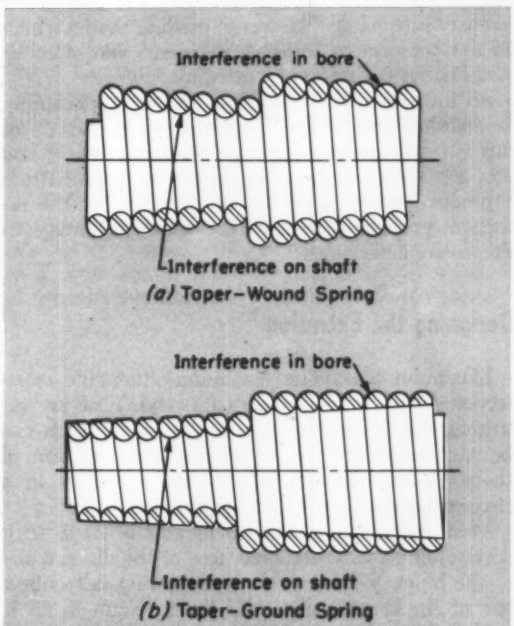


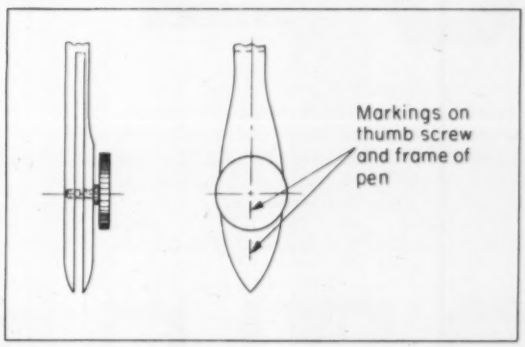

**Fig. 3—Tapered spring types**

**Interference moment increases from the free ends to the bridging coils. Spring *a* has tapers wound into its original shape. Spring *b* is a two-diameter type with tapers ground into the coils. Increasing modulus of ground wire sections effectively increases interference moments.**

# Tips and Techniques

## *Exact Pen Setting*

Exact line weight settings are often lost when ink ruling and bow pens are opened for cleaning. To maintain uniform line weights of pens with thumb screws, mark lines on the screw and body




of the pen when pen is at a desired setting. Thus, when the pen is closed after it has been cleaned, the marks are aligned and the pen is in its original position.—E. J. KICK, *Columbus McKinnon Chain Corp., Tonawanda, N. Y.*

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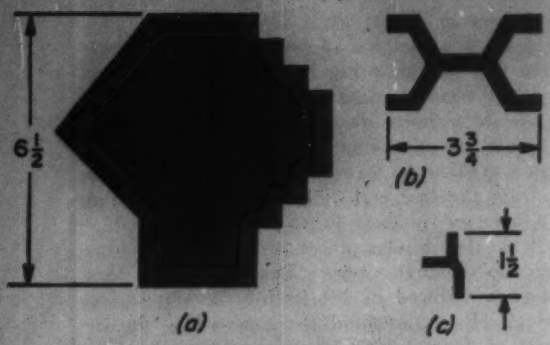
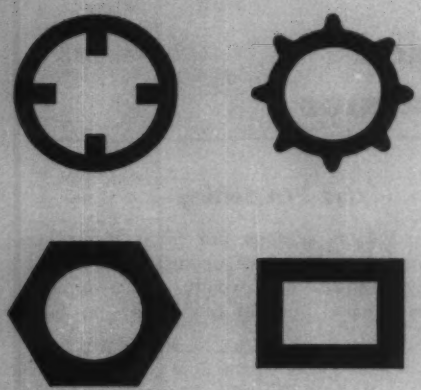



**More usable parts per pound of material** is a very tangible benefit of extruding large shapes, **a.** Savings in material handling and reduction of machining and other fabricating costs are additional benefits where a single extrusion, **b,** replaces a number of welded parts. Control of extrusion variables produces typical light airframe sections, **c,** to within close tolerances. Weight of such sections averages 4 lb per ft.



**A variety of contours** of internal and external surfaces is acomplished economically by extruding tubular and other hollow shapes. The hollow-box type of missile rail would be extremely difficult, if not impossible, to fabricate by a method other than extrusion.

**Difficult to machine,** these semihollow shapes are formed by extrusion plus a secondary operation in some cases. Problems of springback, accessibility where undercuts are encountered, and of set-up or production are thus overcome.

***Design fundamentals***

***Fitting the extrusion to the product***

***How to modify existing shapes***

***Stepped, tapered, and multiple extrusions***

OF PRIMARY interest to designers concerned with the extrusion process are the variety of shapes that can be produced and the design requirements for a good extrusion.

Basically, if a shape conforms to the design requirements imposed by the process itself, the part is termed "extrudable." However, existing shapes which do not conform to these requirements can often be modified for fabrication by extrusion.

An introduction to the process and its applicability to stainless-steel shapes are covered in Part 1 of this two-part series.* This article shows where and how a stainless-steel extrusion can be designed into a product, how shapes can be modified for the extrusion process, and how the most advantageous shapes are determined.

## Designing the Extrusion

**Maximum Size:** The maximum attainable cross-sectional area and length (or weight) of an extrusion depend on the size of the billet which can be accommodated in the press container. Size of shapes is usually limited to those which fit in a circumscribed circle 6½ in. in diameter.

Most shapes are pushed in lengths of 20 to 40 ft depending on cross-sectional area of the die and size of the billet. Where batch heat treating is required, size of the furnace generally limits length to 25 ft.

Usual length-to-thickness ratio of the part cross section is about 10 to 1. For example, if an L-section is ¼ in. thick, maximum length of each leg will be approximately 2½ in. Some extrusions, however, can be produced successfully in maximum length-to-thickness ratios of 16 to 1 or greater. Generally, for channels, depth must be no greater than the width, since the tongue of the die, which forms

*R. E. Paret—"How to Design Stainless-Steel Extrusions," MACHINE DESIGN, Vol. 31, No. 1, January 8, 1959, p. 114.

*How to design*

# STAINLESS-STEEL EXTRUSIONS

## Part 2—Applications and Design Concepts

**By RICHARD E. PARET**
Stainless Steel Specialist
American Iron & Steel Institute
New York, N. Y.

the inner surface of the channel, must be rigidly supported against excessive tool loading to prevent breakage.

Larger cross-sectional areas for stainless-steel extrusions could be obtained if container sizes were increased. However, container diameter is restricted by space considerations necessary for a die insert and back-up tools strong enough to resist extrusion forces. Container size is further limited by the extrusion ratio or the ratio of the transverse area of the billet to the transverse area of the extruded shape.

Tonnage requirements of presses for extruding stainless steel are approximately 84,000 lb of force for each square inch of billet cross section at an extrusion ratio of 20, and 108,000 lb at a ratio of 50. On this basis, presses which accommodate billets of 5 to 6 in. in diameter are generally powered to extrude stainless steel at ratios of 50 or more.

**Minimum Size:** The minimum cross-sectional area which can be extruded depends on pressures necessary to overcome the metal's resistance to flow. Container size, resistance to deformation of the particular type of stainless steel within the extrusion temperature range, shape geometry, and extrusion ratio influence container pressure.

Minimum cross-sectional areas for various stainless-steel grades extruded on a 1778-ton press are shown in Table 1. Minimum web or leg thickness for any extruded shape is approximately $\frac{1}{8}$ in. unless special tooling is used.

**Thin Sections:** During extrusion, the hot metal has a tendency to flow through the mass center of the die or path of least resistance. This characteristic makes it difficult to fill certain sections adequately. This is especially true where unfavorable

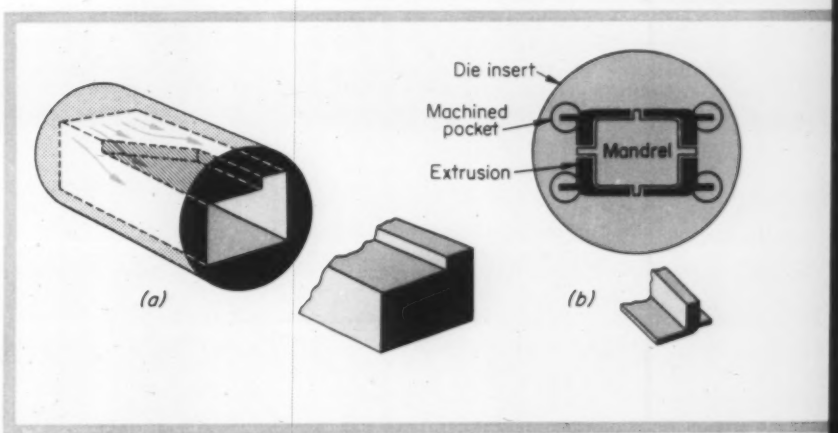



Fig. 1—Overcoming the problem of inadequate filling of irregular shapes during extrusion due to the different thicknesses of adjacent legs of the shape. The land for the top section of the die, *a*, was designed to reduce friction of flow during extrusion and force the metal to fill the die completely. Pockets machined in the die, *b*, also induce increased metal flow to the thin sections

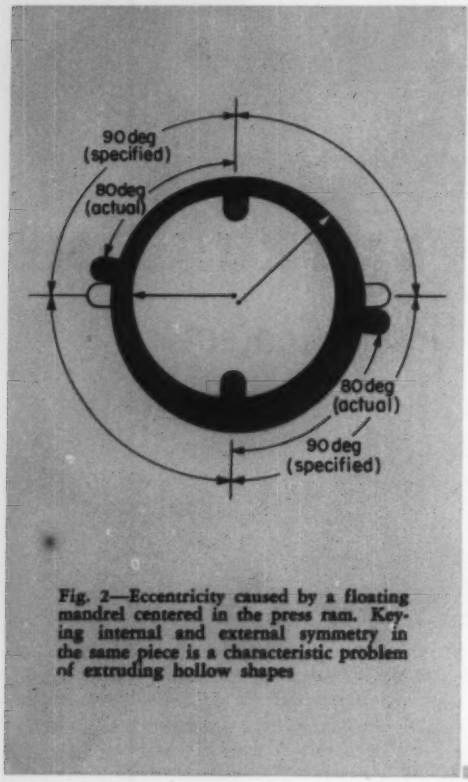



Fig. 2—Eccentricity caused by a floating mandrel centered in the press ram. Keying internal and external symmetry in the same piece is a characteristic problem of extruding hollow shapes

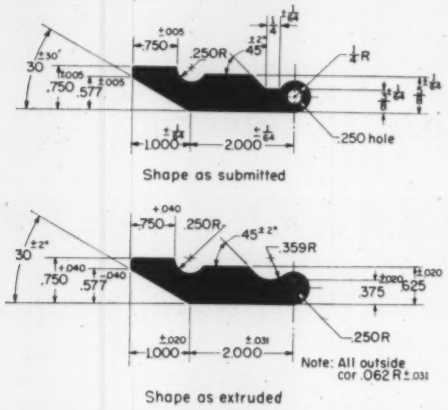



Fig. 3—Redesign of a cam lever for fabrication by extrusion. Although tolerances on the large angle of the extruded part were opened up considerably, the lever, as extruded, was functionally acceptable. Other similarities between the shapes indicate how closely a modified design can approximate that of an existing shape

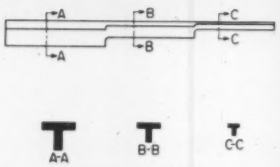



Fig. 4—A stepped part which can be produced either by extrusion alone or by a combination of extrusion and forging. With the latter procedure, production costs are lowered by elimination of the blocking operation required with a forging

geometry exists, such as in the sections of Fig. 1.

Effective die design provides two methods for overcoming the problem. In the first method, Fig. 1*a*, increased metal flow is obtained by reducing friction developed during flow. This produces adequate fill for the entire part. In the second method, Fig. 1*b*, pockets are machined in the die inserts. These open approach areas also induce increased metal flow for proper fill of the added thin areas.

**Tolerances:** Factors which influence tolerance control during extrusion include section design, lubricant control, contraction during cooling, variations in metal flow due to part geometry, and resistance to flow of different alloys at extrusion temperatures. Die design and lubricant control are particularly important when producing shapes with small cross-sectional areas. Here, high extrusion ratios and pressures increase die wear.

Frequent die change is the most effective method for maintaining specified dimensions. Because of low die cost, this practice is entirely feasible within reasonable limits. Many shapes are also extruded to nominal tolerances and cold drawn to close limits which frequently eliminates additional machining.

Specific tolerances attained by extrusion depend to some extent on the geometry of the shape required. Examples of tolerances on various sizes of a solid cross-section are shown in Table 2.

With hollow shapes, major problems are maintenance of concentricity and keying internal and external symmetry or angularity. The possible variations, Fig. 2, result from use of a floating mandrel centered in the press ram. Eccentricity generally will not exceed 10 per cent of wall thickness.

**Fillets and Corners:** Minimum radius of an inside corner fillet is controlled by a sharp die protrusion

**Table 1—Recommended Minimum Size for Stainless-Steel Extrusions***

| Type of Stainless Steel | Minimum Sectional Area (sq. in.) |
|---|---|
| 410 | 0.45 |
| 304, 321, 347 | 0.50 |
| 316 | 0.60 |
| 310 | 0.70 |

*Extrusion container, 5⅝ in. diam.

**Table 2—Tolerances on Solid-Section Extrusions**

| Section Size (in.) | Total Tolerance (in.) |
|---|---|
| Under 1 | 0.031 |
| 1 to 3 | 0.062 |
| 3 to 4 | 0.093 |
| Over 4 | 0.125 |

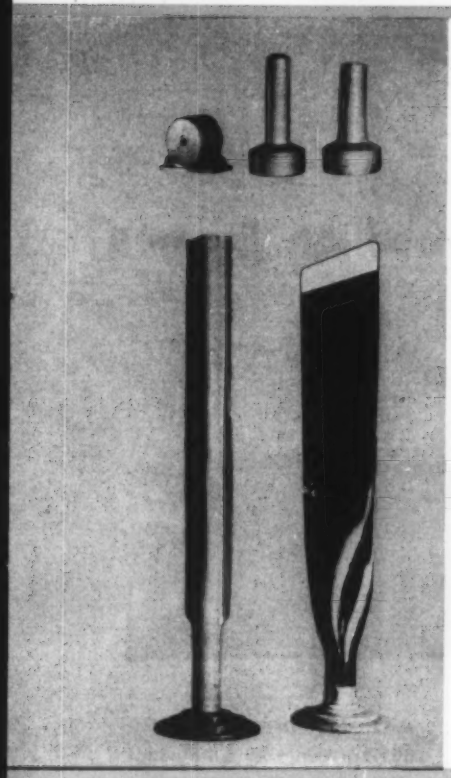
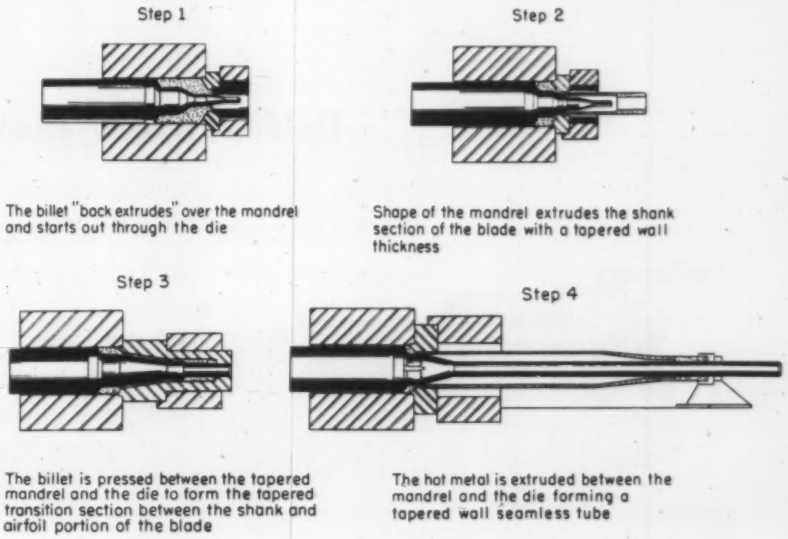


Fig. 5

*Illustrations courtesy of Curtiss-Wright Corp.*


Step 1
Step 2
The billet "back extrudes" over the mandrel and starts out through the die
Shape of the mandrel extrudes the shank section of the blade with a tapered wall thickness
Step 3
Step 4
The billet is pressed between the tapered mandrel and the die to form the tapered transition section between the shank and airfoil portion of the blade
The hot metal is extruded between the mandrel and the die forming a tapered wall seamless tube

**Production of a special extruded hollow part**

in the flowing metal. Fillets are normally produced with radii from 0.125 to 0.438 in. Difficulties of lubrication prevent production of sharp fillets.

Corners are limited by their tendency to fill, to hot tear, or to form cooling cracks. The normal range for corner radii is between 0.031 and 0.125 in.

**Angles:** A tolerance of $\pm 2$ deg can be held on angles. Where length of a projection is less than twice the width, a tolerance of $\frac{1}{2}$ deg can be maintained.

An idea of the functional aspects of these specified tolerances is gained by comparing the shapes in Fig. 3. Shape of the cam lever, redesigned for extrusion, proved functionally effective for the product application. Design adjustments necessary for fabricating the part by extrusion are evident.

**Surface Finish:** Finishes attained depend on the type of stainless steel and conditions of extrusion and are generally as good as or better than those obtained by hot-rolling methods. Cold drawing after extrusion, although primarily specified for tolerance refinement, also improves surface finish.

## Design Potentials of Extrusions

Some of the unusual parts produced so far, and unique production techniques used, indicate the potential of the extrusion process.

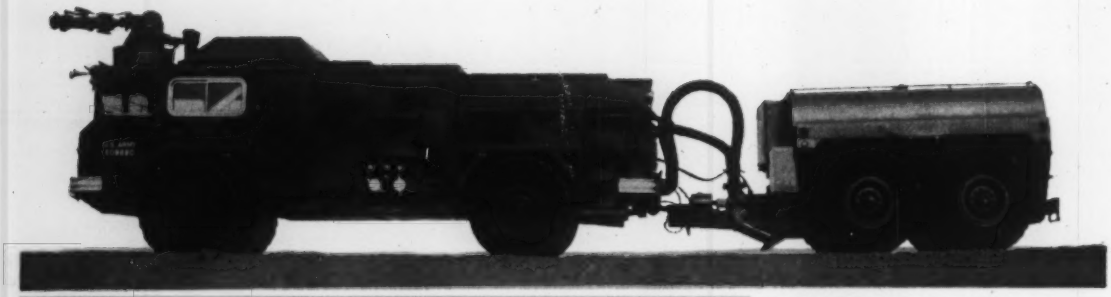
**Stepped Parts:** Occasionally, a part is needed which must vary lengthwise to provide two or more unsymmetrical cross sections, Fig. 4. Special extrusion equipment can produce this typical stepped part, or the section can be extruded with a symmetrical cross section and the steps formed later by forging. Production costs are also reduced with this procedure since the blocking operation required with a forging is eliminated. Shape of a step and its dimensions can be varied.

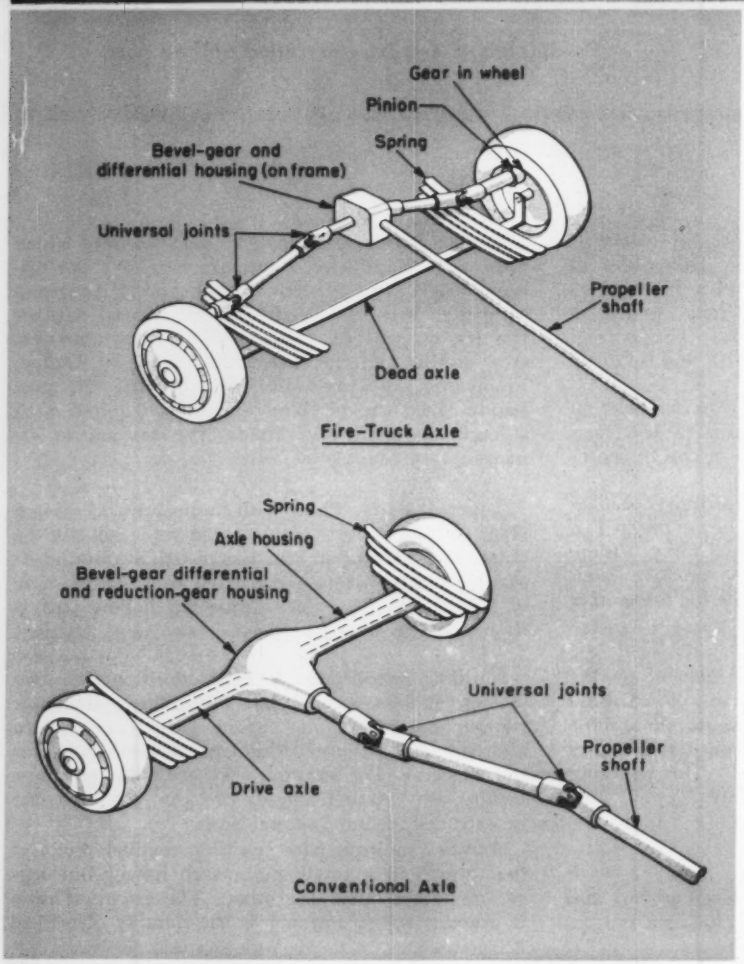
**Tapered Parts:** Parts with uniformly decreasing areas or hollow parts with tapered walls can also be obtained by extrusion and completed by forging or can be formed with a tapered mandrel. An example of production of a special extruded hollow part is shown in Fig. 5.

**Multiple Extrusions:** With multiorifice dies, two or more stainless-steel lengths of similar or dissimilar contour can be extruded in one cycle. This practice affords increased production and reduced costs for the designer. For example, on a 12,000-ton press facility, fifty 20-foot lengths of $\frac{1}{2}$-in. steel rod can be extruded in one 3-second push.

Another multiple-part extrusion method produces four angles in a single push, each having one leg-section thicker than the other. The extrusion ratio is proportionately lowered as the number of orifices is increased.

# Differential Mounted on Frame





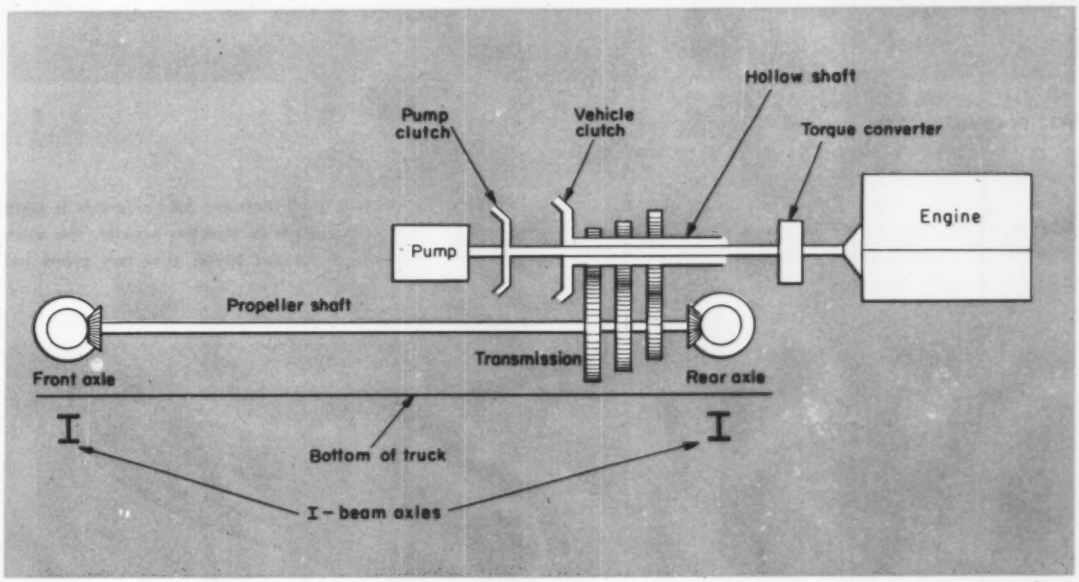

**MAXIMUM OFF-ROAD MOBILITY** is designed into a new military fire truck which combines some of the features of a sports car with the characteristics of a heavy earthmoving machine. As reported by Theodoric B. Edwards, consultant, U. S. Army Engineer Research and Development Laboratories, Ft. Belvoir, Va., the vehicle can travel 60 mph over primary roads and can negotiate cross-country terrain at speeds to 40 mph.

The aluminum truck is designed for use against fires involving unconventional fuels and other large scale fires. It is equipped with a remote-controlled turret and carries a 1000-gallon water tank, a 150-gallon tank for concentrated foam, and a 1500 gpm pump. It is shown with a 2000-gal water trailer attached.

# Reduces Vehicle Unsprung Weight

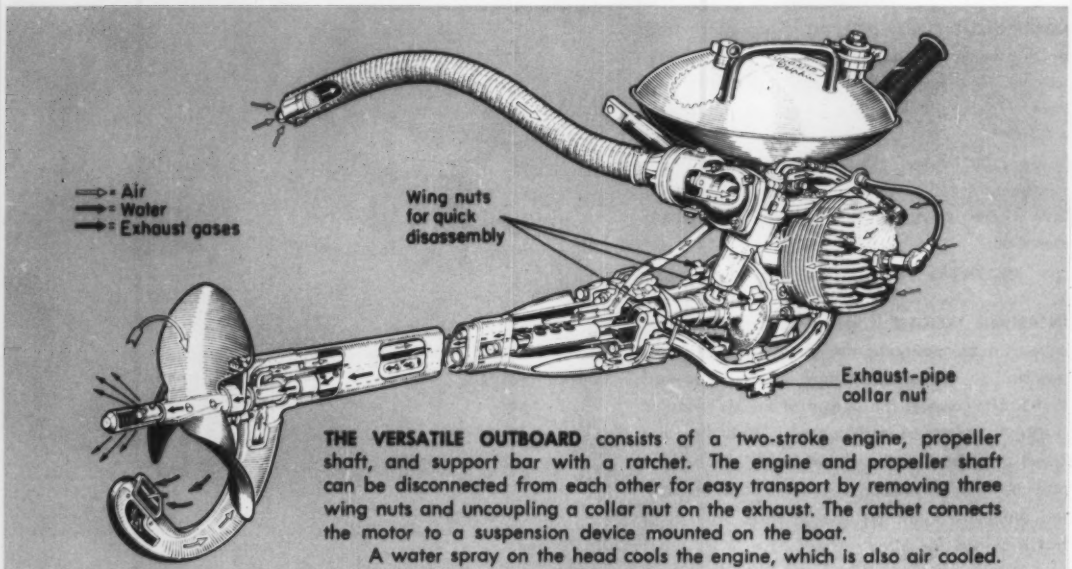
**INDEPENDENT OPERATION** of pump clutch and vehicle clutch makes it possible to maneuver truck at low speeds while pumping water or foam. The pump is driven at full speed directly from the torque converter by a shaft passing through the hollow primary transmission shaft. Engagement or disengagement of the vehicle drive clutch in no way interferes with pump operation.

**UNSPRUNG WEIGHT** is reduced in this 36,000-lb vehicle by mounting the bevel gear and differential on the vehicle frame. Short universal joint shafts connect the output of the differential to internal gears in each wheel. With the final speed reduction in the drivewheels, the torque load on the driveshafts, bevel gears, brakes, and universal joints is reduced to a fraction of that required for direct drive.



# Outboard Motor Mounts on Wooden, Folding, or Rubber Boats

**Side-mounted outboard motor made by Zundapp-Delphin of Germany is designed to mount on wooden boats, inflatable rubber boats, and folding boats. A different basic suspension device is available for each boat type according to O. K. Grade, Grade Engineering Co., Springdale, Conn.**



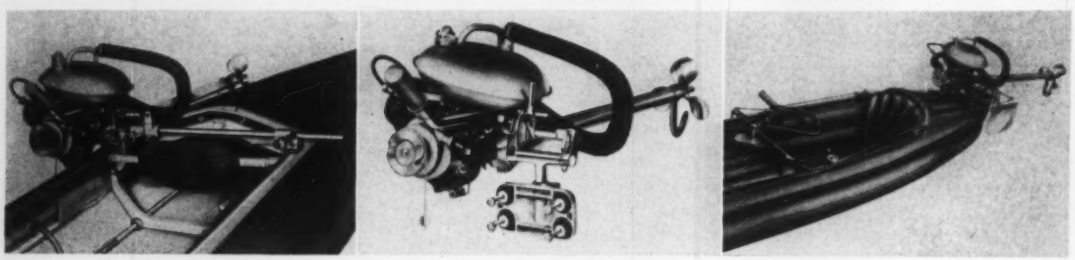

**THE VERSATILE OUTBOARD** consists of a two-stroke engine, propeller shaft, and support bar with a ratchet. The engine and propeller shaft can be disconnected from each other for easy transport by removing three wing nuts and uncoupling a collar nut on the exhaust. The ratchet connects the motor to a suspension device mounted on the boat.

A water spray on the head cools the engine, which is also air cooled. The cooling water enters the support pipe through a strainer-protected hole in the U-shaped skeg and is carried to the spray jet.

**FOR FOLDING BOATS,** the suspension mounting consists of a main support bar on which two clamps can be moved closer together or farther apart.

**FOR WOODEN BOATS,** the mounting device is made up of a base plate with rubber cushions, which are fastened to the boats by four screws.

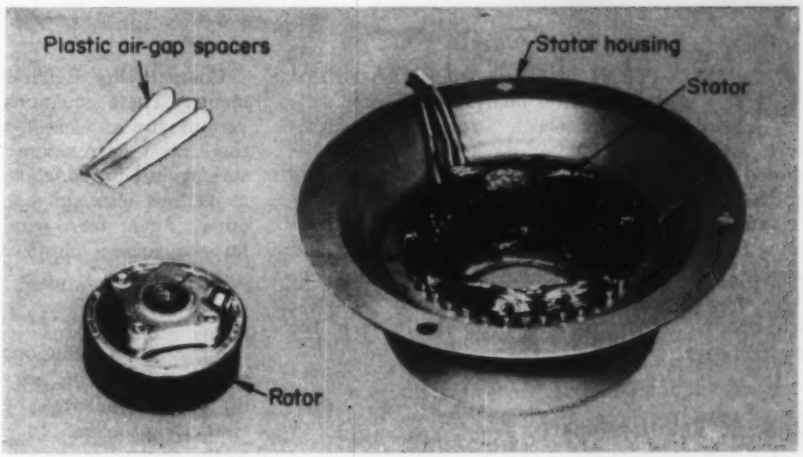
**FASTENING LINKAGE** for Metzeler rubber boats is composed of the front part with steering handle, the stern member with motor support plate, and two pipes between.

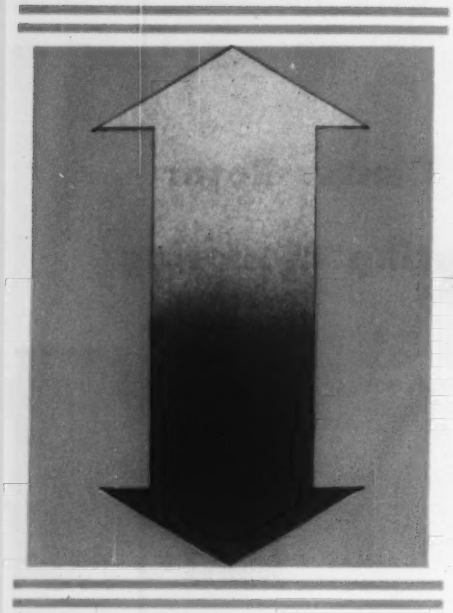


# Removable Spacers Center Rotor in Bearingless Motor During Mounting

**ELECTRIC STARTER MOTOR** for rotary lawnmower fits on engine crankshaft under the mower deck. Built by General Electric, the capacitor-start motor is designed for engines which rotate in a clockwise direction and have standard crankshaft lengths.

**UNIFORM AIR-GAP SPACING** between rotor and stator is achieved with three flat plastic spacers. In assembly, after the rotor is mounted on the crankshaft, the stator and its housing are placed over the rotor. Three slots in the stator housing permit insertion of the spacers establishing a uniform air gap between rotor and stator. The stator housing is then bolted to the engine with mounting bolts and the plastic inserts are removed.





# THERMAL STRESSES

**By S. S. MANSON**
Chief, Materials and Structures Div.
Lewis Research Center, NASA
Cleveland, Ohio

COMPUTATION of elastic stresses is the first step in thermal-stress analysis. For completely brittle materials, elastic stresses govern fracture, and further computations are not usually required. For ductile materials, or in cases where creep is possible, the computed elastic-stress distribution indicates whether further computations must be made to include plastic flow and creep, and serves as a baseline for making such computations. This article presents an outline of a number of methods effective for determining thermal stresses in the elastic range.

## Basic Relationships

Methods used for determining thermal stresses involve several elasticity relationships. Here, discussion of these relationships is limited to two-dimensional problems in rectangular co-ordinates. Corresponding equations for three-dimensional cases, and for other co-ordinate systems, are found in standard texts on elasticity. Discussion also relates primarily to plane-stress problems, and the method of conversion to problems in plane stress is discussed in a later section.

**Equilibrium Equations for Stresses:** These equations arise from the fact that each body element must be in equilibrium under the action of forces imposed upon it. They are identical to those used in any elasticity problem,[6] since they are concerned, not with how these stresses arise, but with relations that exist among the stresses present.

$$\frac{\partial \sigma_x}{\partial x} + \frac{\partial \tau_{xy}}{\partial y} + X = 0 \qquad (14)$$

$$\frac{\partial \sigma_y}{\partial y} + \frac{\partial \tau_{xy}}{\partial x} + Y = 0 \qquad (15)$$

[6]References are tabulated at end of article.

**Compatibility Equations for Strains or Displacements:** These equations state mathematically that various strains cannot vary in a random manner; there must be relations among the strains that insure against introduction of discontinuities in a body as various elements are displaced relative to each other. Again these equations are identical to those for the general elasticity problem,[7] and reduce to

$$\frac{\partial^2 \varepsilon_x}{\partial y^2} + \frac{\partial^2 \varepsilon_y}{\partial x^2} = \frac{\partial^2 \tau_{xy}}{\partial x \partial y} \qquad (16)$$

**Stress-Strain Equations:** The relationships between stresses and strains are the only ones which differ in the thermal-stress problem from the general elasticity problem. In the latter, only strains due to the stresses are present, whereas problems involv-

### Nomenclature

| | |
|---|---|
| $A_n, B_n, C_n$ | = Arbitrary constants for multiply-connected bodies |
| $E$ | = Elastic modulus |
| $h$ | = Thickness |
| $l$ | = Direction cosine |
| $m$ | = Direction cosine |
| $n$ | = Distance normal to boundary surface |
| $r$ | = Radius or radial |
| $S$ | = Distance along boundary surface. |
| $T$ | = Temperature |
| $X, Y$ | = Body forces |
| $X_s, Y_s$ | = Components of boundary stress |
| $\alpha$ | = Coefficient of expansion |
| $\varepsilon$ | = Strain |
| $\mu$ | = Poisson's ratio |
| $\rho$ | = Density of material |
| $\sigma$ | = Normal stress |
| $\tau$ | = Shear stress |
| $\phi$ | = Stress function |
| $\text{del}^2$ | = Laplacian operator |
| $\text{del}^4$ | = Operator |
| $\int_C$ | = Line integral |

# IN DESIGN

## *Part 6—Elastic Stress Analysis*

- **Basic Relationships**
- **Working Equations**

ing temperature changes must include strains due to thermal expansions, $\alpha T$.

$$\varepsilon_x = \frac{1}{E}\left[\sigma_x - \mu(\sigma_y + \sigma_z)\right] + \alpha T \qquad (17)$$

Similar relationships exist for $\varepsilon_y$ and $\varepsilon_z$.

**Boundary Conditions for Stresses or Displacements:** The distinguishing feature among many elasticity problems lies in the type of surface forces or constraints. These surface forces do not show up directly in the differential equations of equilibrium or compatibility, but become important when the equations are integrated and the constants of integration determined. Surface force components[8] are determined in terms of surface stresses by application of equilibrium equations to surface elements.

$$X_s = l\sigma_x + m\tau_{xy} \qquad (18)$$

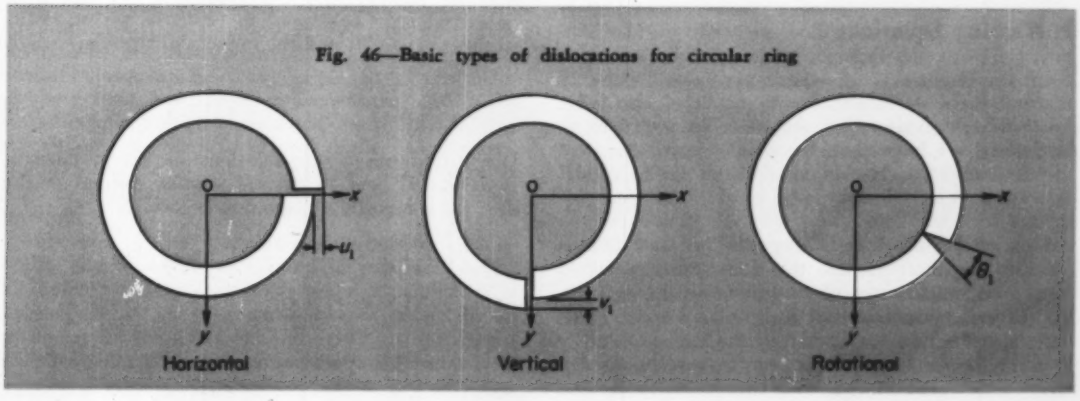
A similar equation exists for $Y_s$.

In most practical cases involving only elastic stress, effects of the thermal stress and of the externally applied loads may be separated and treated independently, and then added to obtain the total stresses. Hence, in determining the thermal stresses, the surface stresses may be taken as zero.

**Special Boundary Conditions:** For multiply-connected regions the surface forces do not completely define the resulting internal-stress system. The most general solution satisfying the temperature distribution and boundary conditions contains three arbitrary constants for each degree of multiplicity; that is, the solution for a body with $n$ separate boundaries in addition to the outside boundary contains $3n$ arbitrary constants. These constants allow for various types of displacements or dislocations, Fig. 46.

For the thermal-stress problem in which only the temperature is varied in the body, none of these

Fig. 46—Basic types of dislocations for circular ring



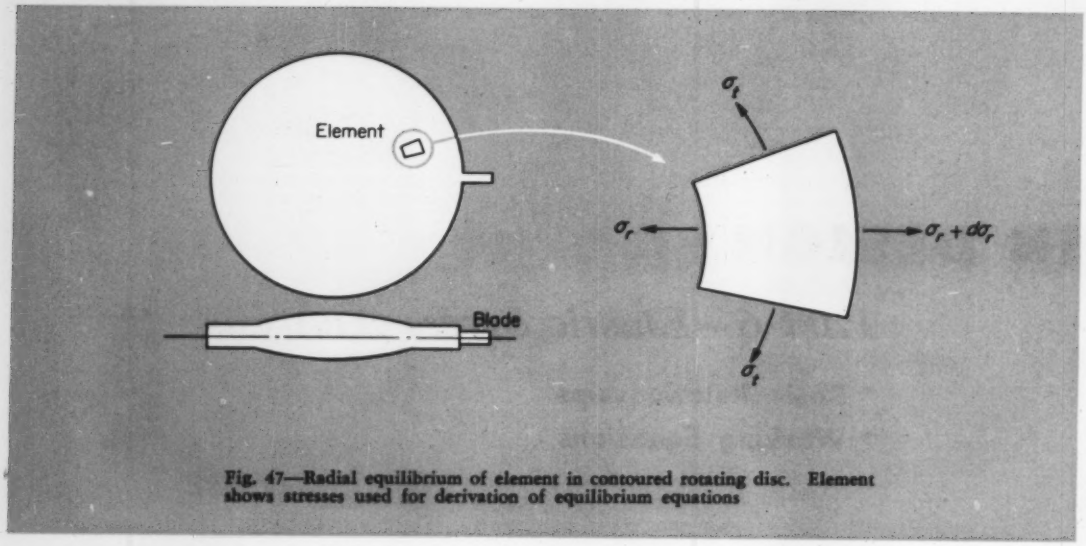



**Fig. 47—Radial equilibrium of element in contoured rotating disc. Element shows stresses used for derivation of equilibrium equations**

dislocations are actually introduced, and the constants must be chosen to make each of these dislocations zero. Equations were first derived by Mitchell[9] but a simple account of the formulation is given by Mindlin and Salvadori.[10] The final equations, for plane stress in which body and surface forces are absent, give stresses which are caused by thermal effects only, not dislocations,

$$\int_c \left[ \frac{\partial(\text{del}^2\,\phi)}{\partial n}\,ds + E\alpha \int_c \frac{\partial T}{\partial n}\,ds = 0 \right. \tag{19}$$

$$\int_c \left[ y\frac{\partial(\text{del}^2\,\phi)}{\partial n} - x\frac{\partial(\text{del}^2\,\phi)}{\partial s}\,ds \right] + E\alpha \int_c \left( y\frac{\partial T}{\partial n} - x\frac{\partial T}{\partial S} \right) ds = 0 \tag{20}$$

$$\int_c \left[ y\frac{\partial(\text{del}^2\,\phi)}{\partial s} + x\frac{\partial(\text{del}^2\,\phi)}{\partial n} \right] ds + E\alpha \int_c \left( y\frac{\partial T}{\partial s} + x\frac{\partial T}{\partial n} \right) ds = 0 \tag{21}$$

where $\text{del}^2 = (\partial^2/\partial x^2) + (\partial^2/\partial y^2)$

## Working Equations

In the derivation of equations for solutions of thermal-stress problems, use is made of the basic relationships previously discussed. The equations to be defined are important, but also of importance are the methods of derivation, since these methods indicate analysis techniques.

**Use of Equilibrium, Compatibility, and Stress-Strain:** The most general two-dimensional problem involves six unknowns of stress and strain, expressible in general differential equations. Rarely, however, is it desirable to start with the six equations in a particular problem. It is best to manipulate the large set of general equations into a single general equation in one unknown quantity and to determine all stresses and strains of interest in terms of this quantity. This quantity is known as the stress function and is described later. Sometimes, however, it is best to resort to the concepts involved in the conditions of equilibrium and compatibility to arrive at a final working equation simply and directly. This approach is particularly valid in simple cases involving symmetry, or when it is obvious that some of the stress and strain components can be omitted.

To illustrate this approach, the three-dimensional nature of the rotating contoured disc with temperature gradient, Fig. 47, is taken into account only insofar as the thickness changes with radius.[11] Considering the equilibrium of a radial element and recognizing that shear stresses vanish because of symmetry, the only nontrivial equation becomes that of radial equilibrium:

$$\frac{d}{dr}(rh\sigma_r) - h\sigma_t + \rho w^2 r^2 h = 0 \tag{22}$$

For the compatibility equation, the strains are expressed in terms of displacements. In this case, only the radial displacement $u$ of an element need be considered. Expressed in terms of $u$, the radial strain $\varepsilon_r = du/dr$ and the tangential strain $\varepsilon_t = u/r$, from which

$$\varepsilon_r = \frac{d}{dr}(r\varepsilon_t) \tag{23}$$

Using the stress-strain relations similar to those of Equation 17 and neglecting stresses normal to the disc, the compatibility equation becomes

$$\frac{d}{dr}\left(\frac{\sigma_t}{E}\right) - \frac{d}{dr}\left(\frac{\mu\sigma_r}{E}\right) + \frac{d}{dr}(\alpha T) - \frac{(1+\mu)(\sigma_r - \sigma_t)}{Er} = 0 \tag{24}$$

The values for $\sigma_r$ and $\sigma_t$ are found by solving Equations 23 and 24 simultaneously.

**Equivalent Body and Surface Forces:** The simplest way of setting up a thermal-stress problem is to replace it by an equivalent problem of known body and surface forces. The body is first imagined dissected into a number of elemental units, and each unit is constrained from any thermal expansion due to its temperature by the application of suitable external forces. Fortunately, because shear stresses are absent in the dissected system it is very simple to determine the necessary force system to produce the constraint by reference to elementary considerations or to the equilibrium equations.

The body is then imagined re-connected in its constrained form so that it has exactly the same shape as before the change of temperature. The external forces are then removed. This is equivalent to considering the application of a force system of equal magnitude but opposite sign. However, since the force system is now applied to the continuous body wherein shear stresses can exist, the problem of determining the stress distribution due to the force system can become complicated and must be treated as a general elasticity problem.

Use can also be made of simplifications normally introduced in elasticity problems. Once the stresses are determined for the equivalent loading problem they are added to the initial stresses introduced by the constraining system in the dissected term, yielding the net stresses. This approach in its most elementary form is best illustrated by using a simple symmetrical blade, Fig. 48. A temperature distribution $T = T_x(x)$ is assumed along the blade chord, but along any chordal dimension the temperature is constant through the thickness and along the blade length.

Imagine that the blade is divided into a series of slits by cuts along the entire length. Each slit is at uniform temperature and, hence, will expand freely in the axial direction an amount $\alpha T_x$. Now, imagine that each of the slits is brought back to its initial dimension by application of a compressive stress, $\sigma = E\alpha T_x$. Since the blade now has its original dimensions, it can be reglued along the initial cuts.

This system now differs from the initial blade by the presence of an edge stress $\sigma = -E\alpha T_x$. To make the two the same, a positive stress $E\alpha T_x$ is applied along the edge. Every point in the reglued body now has added to it a stress associated with the external edge stress system $\sigma = E\alpha T_x$. In the reglued body, however, the elemental slits are not free to strain independently. They strain as a continuous elastic system, and the stress distribution due to the external force system is obtained according to elastic theory. In the vicinity of the applied edge forces, the localized stress system becomes fairly complex and is analyzed by application of more rigorous methods.

However, if the blade is long compared to its width, the stresses remote from the edge are readily determined by applying St. Venant's principle.[12] The applied surface stress system may be replaced by its static equivalent, that is, its resultant force and moment. The blade is then treated as a beam with force and moment applied.

GENERAL APPROACH USING DUHAMEL'S ANALOGY: The approach previously discussed is easily extended to more complex cases of two and three dimensions. In the most general three-dimensional case, the first step is to imagine each element cut out and separated from its neighbors. Free to expand, each element would elongate equally in all directions an amount $\alpha T$. Hence, $\varepsilon_x = \varepsilon_y = \varepsilon_z = \alpha T$ and $\tau_{xy} = \tau_{yz} = \tau_{xz} = 0$, since uniform expansions do not introduce shearing strains. Next, imagine external loads applied to each element to force it back to the original dimension. Such loads must be equal in all directions and of magnitude $\sigma_x = \sigma_y = -E\alpha T/(1 - 2\mu)$. The term $(1 - 2\mu)$ takes into account the Poisson's ratio effect of the three-dimensional stress system, and no shear stresses are needed. All elements now have their original size and fit together perfectly as separate elements without shear stress between them.

Equilibrium equations alone suffice to establish the forces that will produce an internal stress system of $\sigma_x = \sigma_y = \sigma_z = -E\alpha T/(1 - 2\mu)$ and $\tau_{xy} = \tau_{yz} = \tau_{xz} = 0$. The equations apply whether the body is continuous or segmented, but in the segmented form, simplification arises because the shear terms are absent. Equations 14 and 15 are valid in three as well as two-dimensional cases. Therefore these equations and a similar symmetric equation in the z direction are applied to obtain the required body forces, assuming $E$ and $\mu$ as constants.

$$X = \frac{\alpha E}{(1 - 2\mu)} \frac{\partial T}{\partial x} \qquad Y = \frac{\alpha E}{(1 - 2\mu)} \frac{\partial T}{\partial y}$$

$$Z = \frac{\alpha E}{(1 - 2\mu)} \frac{\partial T}{\partial z} \tag{25}$$

Stresses at the surface must be consistent with the requirement of hydrostatic pressure, so a normal stress $\sigma = -E\alpha T/(1 - 2\mu)$ is also required on each element of surface.

The body in its segmented form, but of restored shape, differs from the true body in three respects: (1) No shear stresses are permitted between adjacent elements, although they fit perfectly together to form a body of the original shape. (2) The external loading system given by Equation 25 is present. (3) Each element is subject to a hydrostatic stress $\sigma = -E\alpha T/(1 - 2\mu)$.

To bring the two bodies into coincidence, the segments must be joined together and the imaginary external force system removed. It is emphasized that when the imaginary external force system is removed from the continuous, joined body, the effects of the system are different from those on the segmented body. The problem becomes one in the elasticity of the continuous body subjected to the force system of Equation 25 with opposite sign. This force system introduces shear stresses because of the continuity of the body.

As a result of the foregoing discussion, it is possible to reformulate any thermal-stress problem in terms of a body and surface force problem in the following manner.

Let the body be initially at zero stress under uni-

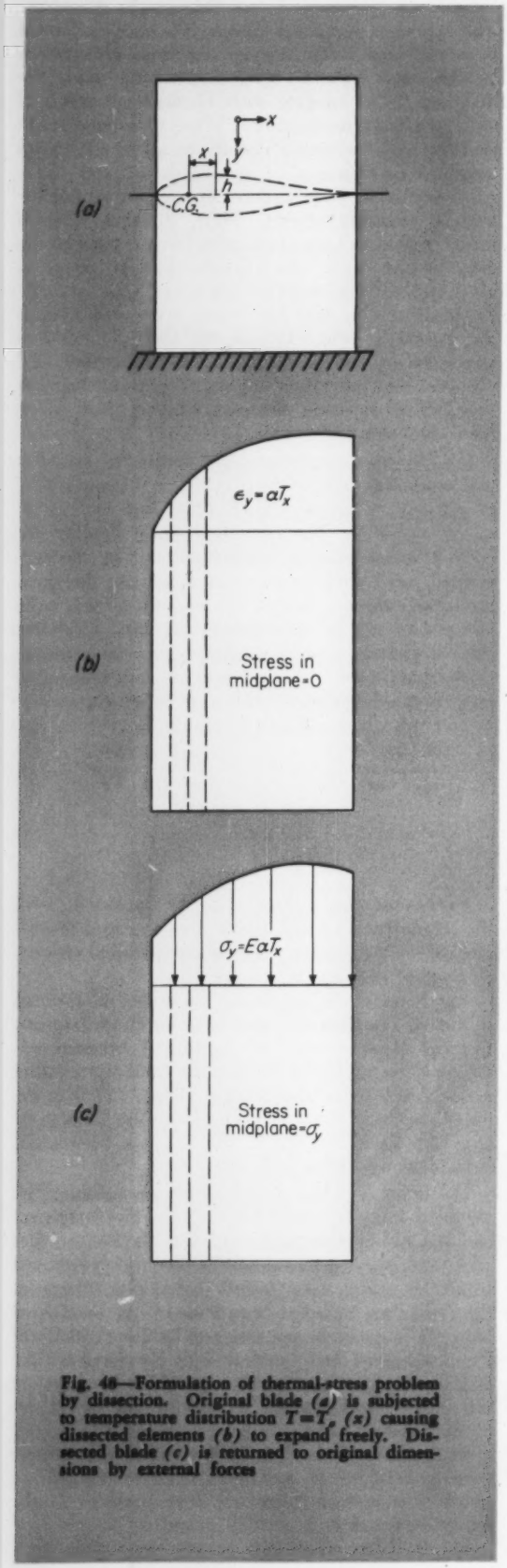



**Fig. 48—Formulation of thermal-stress problem by dissection. Original blade *(a)* is subjected to temperature distribution $T = T_x$ *(x)* causing dissected elements *(b)* to expand freely. Dissected blade *(c)* is returned to original dimensions by external forces**

form temperature. If the temperature at each point $(x, y, z)$ is increased by a value $T(x, y, z)$, then the thermal stresses that result are equal to the stresses in the same body obtained as follows:

1. Apply to each element of volume throughout the body a body force having the components of Equation 25 per unit volume, but of opposite sign.
2. Apply at every point on the surface a force per unit area of $E\alpha T/(1 - 2\mu)$.
3. Solve for the elastic stresses $\sigma_x$, $\sigma_y$, $\sigma_z$ in this hypothetical elasticity problem; and add to each of these stresses the stress $\sigma = -E\alpha T/(1 - 2\mu)$ to obtain the true stresses $\sigma_x'$, $\sigma_y'$, $\sigma_z'$.

In the foregoing analysis, the body forces are hypothetical and should not be confused with true body forces, which might actually be applied on the body. Where such actual body forces are applied, their effects should be separately determined and superimposed on the above stresses.

SIMPLIFICATION: It is not always necessary to constrain the expansions in all three directions during the first stage of problem setup. If the plate is thin, the constraint may be limited to expansions in the $xy$ plane. This permits the necessary expansion in the $z$ direction, due to thermal effects and constraint in the $xy$ plane. While this violates some of the conditions of compatibility, it is usually permissible without introducing serious error. The procedure then follows the same line of reasoning, with $(1 - 2\mu)$ replaced by $(1 - \mu)$, and all stresses in the $z$-direction neglected.

The concept can be carried one step further by applying the constraint in only one direction, as in the blade problem. Strictly evaluated, this procedure is not correct. Although the mechanical loading system restores the longitudinal elements to their original size, they still do not fit in the other dimensions. However, if the transverse dimensions are small in comparison with the longitudinal dimensions, violation of the compatibility conditions may introduce little error. In this case the $(1 - 2\mu)$ term is replaced by unity.

Whether the problem is set up in a one, two, or three-dimensional form greatly affects the complexity of the solution, while in some cases the final result is not greatly affected.

Therefore, when a new problem is set up, constraints should be kept at a minimum in order to simplify the formulation. Sometimes it is desirable to follow up a one-dimensional formulation by a two-dimensional one, with the solution of the former as a guide for solving the latter.

**Use of Stress-Functions:** If a function $\phi$, known as a stress function, can be found so that

$$\sigma_x = \frac{\partial^2 \phi}{\partial y^2} \qquad \sigma_y = \frac{\partial^2 \phi}{\partial x^2} \qquad \tau_{xy} = -\frac{\partial^2 \phi}{\partial x \partial y} \qquad (26)$$

then the equilibrium Equations 14 and 15 will automatically be satisfied for X and Y = 0.

Considering the plane-stress problem, the strains are expressed in terms of the stress function by use of Equations 20 and 26, neglecting $\sigma_z$. Substituting these strains into the compatibility Equation 16 results in the biharmonic equation

$$\text{del}^4\phi + E\alpha\,\text{del}^2 T = 0 \tag{27}$$

where

$$\text{del}^4 = \frac{\partial^4}{\partial x^4} + \frac{2\partial^4}{\partial x^2\,\partial y^2} + \frac{\partial^4}{\partial y^4}$$

Thus, if Equation 27 is solved for $\phi$ the stresses can be determined from Equation 26. In solving for $\phi$ from Equation 27, boundary conditions must be imposed. These are obtained from the fact that the normal and shear stresses on each surface are zero. Substitution of these stresses, in terms of the stress function, into the boundary conditions Equation 18 results in

$$\frac{\partial^2\phi}{\partial y^2}\frac{dy}{ds} + \frac{\partial^2\phi}{\partial x\,\partial y}\frac{dx}{ds} = 0 \text{ or } \frac{d}{ds}\frac{\partial\phi}{\partial y} = 0 \tag{28}$$

and

$$\frac{\partial^2\phi}{\partial x\,\partial y}\frac{dy}{ds} + \frac{\partial^2\phi}{\partial x^2}\frac{dx}{ds} = 0 \text{ or } \frac{d}{ds}\frac{\partial\phi}{\partial x} = 0 \tag{29}$$

Integrating Equations 28 and 29,

$$\frac{\partial\phi}{\partial x} = a \qquad \frac{\partial\phi}{\partial y} = b \tag{30}$$

along any boundary. Here, $a$ and $b$ are arbitrary constants. These equations are satisfied if along each boundary,

$$\phi = ax + by + c \tag{31}$$

If the body has only one boundary, $a$, $b$, and $c$ can be taken equal to zero, since a stress function which is linear in $x$ and $y$ can be added to the solution without affecting the stresses. The arbitrary addition can thus be made to cause the boundary values and derivatives to be zero. If there is more than one boundary, then the arbitrary addition can cause the stress functions and derivatives to vanish at one boundary only. There will still remain nonzero values at the other boundaries.

The boundary conditions to be used in conjunction with the biharmonic solution are; for a singly-connected region or for the outer (or any other single) boundary of a multiply-connected region,

$$\phi = \frac{\partial\phi}{\partial x} = \frac{\partial\phi}{\partial y} = 0 \tag{32}$$

and for each of the other boundaries of a multiply-connected region

$$\phi = a_n x + b_n y + c_n \tag{33}$$

and

$$\frac{\partial\phi}{\partial x} = a_n \qquad \frac{\partial\phi}{\partial y} = b_n \tag{34}$$

Equation 33 gives the values on the boundary while Equations 34 provide information on how the stress function varies just inside the boundary. Actually, there is a slight redundancy here, since either of Equations 34 in conjunction with Equation 33 provides the same total information. Application of these equations will be illustrated in a later article.

**Formulation of Plane-Strain Problems:** A comparison of derivations of plane-stress problems shows that all formulas for the case of plane stress can be converted to plane strain by replacing $E$, $\mu$, and $\alpha$ by $E'$, $\mu'$, and $\alpha'$ where

$$E' = \frac{E(1+2\mu)}{(1+\mu)^2} \qquad \mu' = \frac{\mu}{(1+2\mu)} \qquad \alpha' = \frac{\alpha(1+\mu)}{(1+2\mu)}$$

Hence, for the case of plane strain, the biharmonic Equation 27 is replaced by a similar equation in which $E\alpha$ becomes $E\alpha/(1+\mu)$. Similarly, the single-valuedness conditions, Equations 19, 20, and 21, become the same relations with $E\alpha$ replaced by $E\alpha/(1+\mu)$.

**The next article** in this series will discuss the solution of thermal stress problems in the elastic region by exact methods and by the application of the beam theory.

### References

This article is the sixth in a series by S. S. Manson on thermal stresses in design. Previous articles and issues of MACHINE DESIGN in which they appeared are:

1. "Appraisal of Brittle Materials" ..... June 12, 1958
2. "Quantitative Techniques for Brittle Materials" . June 26, 1958
3. "Basic Concepts of Fatigue in Ductile Materials" August 7, 1958
4. "Causes of Fatigue in Ductile Materials" .... August 21, 1958
5. "Interpretation of Fatigue Data for Ductile Materials" ..... September 4, 1958

Other references mentioned in this article are:


6. S. Timoshenko and J. N. Goodier—*Theory of Elasticity*, McGraw-Hill Book Co. Inc., New York, 1951, p. 228.
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8. Reference 6, p. 23.
9. J. H. Mitchell—"Direct Determination of Stress in an Elastic Solid, with Application to the Theory of Plates," *Proc. of London Mathematical Society*, Vol. 31, 1899, pp. 100-124.
10. *Handbook of Experimental Stress Analysis*, edited by M. Hetenyi, John Wiley and Sons Inc., 1950, pp. 700-827.
11. S. S. Manson—"Determination of Elastic Stresses in Gas Turbine Discs," NACA Report 871, 1947.
12. Reference 6, p. 33.


# They Say . . .

"Engineering and science have brought our civilization to its present stature. They have the responsibility to participate in seeing to it that it is used for creative rather than destructive ends."—LOUIS R. HOWSON, *president, American Society of Civil Engineers.*

"Technology is not just a means of displacing labor. It produces more things for all with less labor and more relaxation for all." — LOUIS R. HOWSON, *president, American Society of Civil Engineers.*

"We have been living in a period of raw material luxury. Now we face ever-increasing periods of poverty of natural resources. Conservation, substitution, and replacement must be essential ingredients of our future economy."—JOHN T. RETTALIATA, *president, Illinois Institute of Technology.*

*Not often associated with structural functions, graphite parts have exhibited surprising ruggedness in critical rocket and missile applications. Increase in strength with temperature, chemical inertness, and excellent machinability make this material desirable for many applications. Its versatility is further increased by the fact that it can be plated, coated, and impregnated with a variety of other materials. Here are the basic factors in designing . . .*

# MACHINED GRAPHITE

*In a baptism of fire in its truest sense, these rocket parts prove that graphite is capable of withstanding extremely high combustion temperatures plus erosion. Fuel liners, top, and discharge vanes, bottom, were machined from graphite blocks. Complexity of contours of the vanes, edge-sharpness, and surface finish attainable show graphite to be a versatile material*



MACHINED GRAPHITE COMPONENTS

By LEO SIMBECK,
FRANCIS WEISNER,
I. L. HARVEY
Carbon Products Div.
Speer Carbon Co.
St. Marys, Pa.

# COMPONENTS

BECAUSE graphite has proved to be capable of withstanding the imposed operating conditions of temperature and erosion, it is currently used for solid-fuel rocket nozzle inserts and for divergent cone sections. It is also used to a limited extent for liners and vanes in the discharge portion of the rocket. Excellent heat conductivity and rapid dissipation of heat make graphite suitable for heat exchangers, bearings, brushes, and seals in other sections of the rocket.

The majority of these components, machined from commercially available graphite blocks, incorporate design practices which are recommended here for other high-temperature parts.

**Properties:** Graphite not only has excellent thermal shock resistance but is unique in that strength increases with temperature, Fig. 1. It is 99 per cent chemically pure and resists reaction with almost any other substance. This "machinable ceramic" can be machined into practically any prescribed shape within extremely close tolerances and with a minimum of special equipment.

Graphite can be given additional properties, or desirable properties can be augmented, by means of coatings, impregnations, and plating processes. It is commercially impregnated with a variety of resins, waxes, and oils and with such metals as copper and silver. Graphite can be coated with aluminum oxide, zirconium oxide, silicon carbide, and other protective coatings. It can be plated with any metal that can be deposited by electroplating.

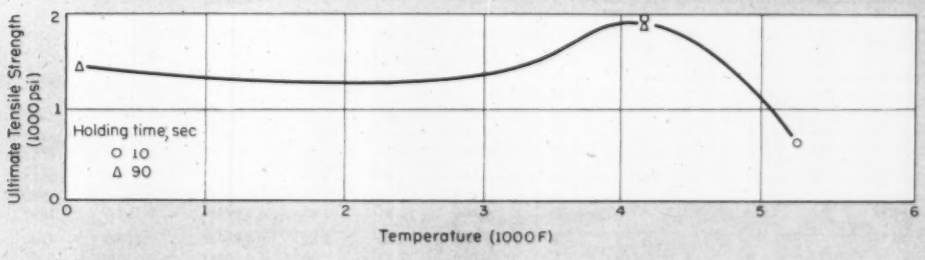



Fig. 1—Effect of temperature on ultimate tensile strength of graphite. Nominal strain rate is 0.00005 in. per in. per sec. Specimen was heated to test temperature within 20 sec. Increase in tensile strength with temperature is a characteristic of graphite which is advantageous in many high-temperature applications

In many applications, impregnations and coatings are used to prolong the life of the graphite component. In rockets, for example, erosion by high-velocity gases has been reduced by as much as 40 per cent by such processes.

Graphite is a relatively light material with a specific gravity of only 1.5 to 1.8. Thus, graphite components have added a minimum to over-all weight of critical missile installations.

**Component Size:** To date, few applications have required the size of graphite components to exceed 24 in. in diameter and 40 in. in length. Such components have been fabricated from a single block of graphite. However, these dimensions should not be considered the ultimate limit, since larger blocks are possible and, for very large components, sections are laminated from small blocks. Recommended minimum size of graphite parts is approximately ½ in. diam and 3/16 in. long.

**Available Shapes:** Manufactured graphite (electrographite) is available in molded and extruded shapes of various sizes and grades, Table 1. Electrographite contains flour of a certain fineness and a suitable binder. Extruded and molded shapes are baked for approximately one month at 1800 F to set the binder. Conversion to graphite is accomplished by furnace processing at 4000 to 5500 F. This graphitizing process may take an additional month to complete—a factor which affects availability to some extent. Processing techniques vary, but formulation of each grade is closely controlled to insure duplication of properties and performance characteristics.

**Design Recommendations:** Graphite can be machined to extremely close tolerances, but cost of fabrication increases as tolerances decrease. At present, tolerances on inside diameters are maintained at ±0.002 in. per inch to a maximum of ±0.010 in. Tolerances on outside diameters are ±0.002 in. for diameters to 5 in. and ±0.004 in. for larger diameters. An example of recommended tolerances on critical dimensions of an actual graphite rocket part is shown in Fig. 2.

Certain design features should be avoided whenever possible because of the nature of graphite. For example, knife edges always present a chipping problem during manufacturing, shipping, and final assembly. Where possible, flat or chamfered edges are preferable. Similarly, outside corners are subject to chipping and notching, and design modifications such as chamfers or radii should be provided to protect against damage. In some instances, a small collar or step can be machined onto a part as a protective device and subsequently removed at the user's plant during final assembly.

**Fabrication Problems:** While most design requirements can be met by the graphite manufacturer, some users suggest that fabrication of components might best be accomplished at their plants to expedite production, eliminate shipping and handling of complex parts, and cut costs.

However, machining of graphite involves specialized techniques and presents some unusual problems. While most machining is done with standard tools, special procedures must be followed to offset the problem of dust, for example, with special dust-collecting systems. Graphite dust is abrasive and potentially destructive to machine tools. It is also electrically conductive and a safety hazard because of its slipperiness.

Special handling techniques are required during manufacturing to prevent chipping, splitting, and notching. Unless graphite is handled properly, rejects and scrap loss are unnecessarily high. For these reasons, it is preferable that as much machining as possible be handled by the manufacturer.

**Table 1—Available Sizes and Properties of Electrographite Blocks**

| Section Shape | | | | | Process | | Maximum Particle Size | Density (grams/cc) | | | Resistance (ohm-in.) | | Transverse Strength (psi) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Round* | | Rectangular* | | | Molded | Extruded | (in.) | Specified Min | Typical | Specified Max | Typical | Specified Min | Typical |
| Diam | Length | Length | Width | Thickness | | | | | | | | | |
| 6½ | 12 | | | | X | | 0.008 | 1.60 | 1.65 | 0.00055 | 0.00040 | 3000 | 3900 |
| 14½ | 5 | | | | X | | | | | | | | |
| | | 12 | 12 | 2½ | X | | 0.008 | 1.60 | 1.64 | 0.00050 | 0.00040 | 3000 | 3850 |
| to 1 | to 24 | | | | | X | 0.008 | 1.63 | 1.75 | 0.0005 | 0.00045 | 2900 | 7000 |
| 1⅛ to 2⅝ | to 24 | 8 | 3 | to 1⅞ | | X | 0.008 | 1.63 | 1.73 | 0.0005 | 0.00045 | 2600 | 3100 |
| | | 12 | 3 | 1¼ | | X | | | | | | | |
| 2½ to 5 | to 48 | | | | | X | 0.008 | 1.60 | 1.63 | 0.0005 | 0.00045 | 2300 | 2800 |
| 3 to 14 | to 72 | 48 | 8 | 8 | | X | 0.032 | 1.60 | 1.68 | 0.0004 | 0.00029 | 1900 | 2600 |
| 3 to 14 | to 72 | 48 | 8 | 8 | | X | 0.032 | 1.65 | 1.75 | 0.00041 | 0.00025 | 2200 | 2400 |
| 16 to 24 | to 72 | 72 | 16 | 16 | | X | 0.032 | 1.60 | 1.78 | 0.00043 | 0.00030 | 1900 | † |
| to 2⅝ | to 24 | | | | | X | 0.008 | 1.60 | 1.69 | 0.0004 | 0.00027 | 2400 | 2500 |
| 2½ to 8½ | to 72 | | | | | X | 0.008 | 1.60 | 1.63 | 0.0004 | 0.00027 | 2400 | 2600 |
| 9 to 24 | to 72 | | | | | X | 0.032 | 1.50 | 1.52 | 0.00048 | 0.00033 | 1600 | 2000 |
| | | 72 | 9 | 3 | | X | 0.008 | 1.48 | 1.55 | 0.00047 | 0.00035 | 2000 | 3600 |
| | | 72 | 9 | 3 | | X | 0.008 | 1.60 | 1.65 | 0.00043 | 0.00033 | 2500 | 4500 |
| | | 72 | 16 | 16 | | X | 0.032 | 1.48 | 1.55 | 0.00047 | 0.00035 | 1500 | 1800 |
| | | 72 | 12⅝ | 4⅛ | | X | 0.032 | 1.60 | 1.65 | 0.00043 | 0.00033 | 2000 | 3000 |
| 5 to 14 | to 60 | 48 | 8 | 8 | | X | 0.032 | 1.60 | 1.72 | 0.00045 | 0.00027 | 2000 | 2700 |
| 3 to 14 | to 72 | 48 | 8 | 8 | | X | 0.032 | Design density | Approx. 1.85 | 0.00045 | † | 2000 | † |

*All dimensions in inches. †Not available

All graphite parts presently required for rockets and missiles must be machined from stock rather than cast or molded because of shrinkage and other factors involved in baking and graphitizing. Casting and molding is commonly used for many types of small components. Lead time for baking and graphitizing large cast or molded parts would run into several months, whereas the same parts are machined from stock in much less time.

Graphite cannot be machined to the same degree of surface finish as metals, nor can the finish be measured in the same way. Because of its high porosity (to 30 per cent), graphite's surface finish depends upon particle size, properties, and machining techniques. Porosity is an advantageous property because it increases resistance to thermal shock.

**Joining Methods:** Circular parts are usually joined by interference or force fits for OD sizes under 8 in. Such parts must be manufactured within a tolerance of 0.003 in. on dimensions of the receiving member. Large graphite inserts are joined to dissimilar parts by shrink fitting. Metallic parts can be expanded by heating and the graphite part inserted. Graphite can also be joined to other parts by threading and fastening with standard bolts. A coarse-thread series is preferred in this method.

Cements have been used with graphite to some extent but are not effective at elevated temperatures. In the present missile and rocket applications mentioned, they serve merely to hold the part in place until used. No entirely satisfactory cement has been developed for graphite to date.

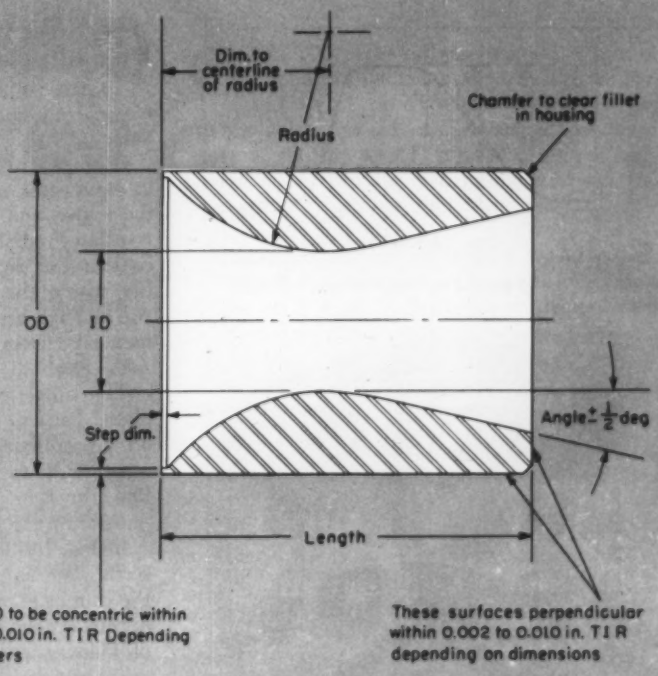
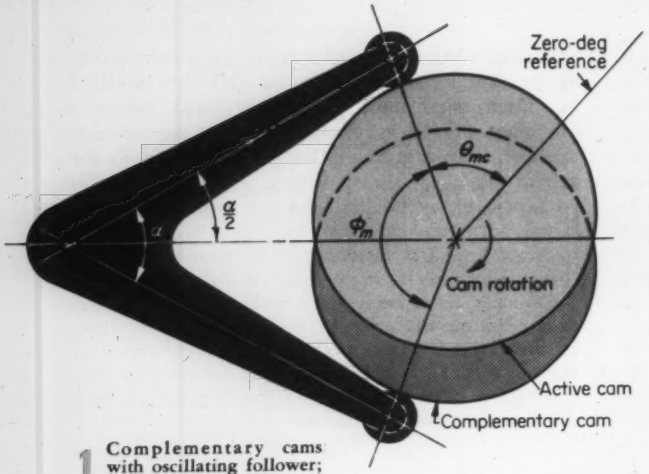

Dim. to centerline of radius
Radius
Chamfer to clear fillet in housing
OD
ID
Step dim.
Angle ± ½ deg
Length
ID and OD to be concentric within 0.002 to 0.010 in. TIR Depending on diameters
These surfaces perpendicular within 0.002 to 0.010 in. TIR depending on dimensions

**Fig. 2—Typical tolerances on critical dimensions of actual rocket nozzle insert. These tolerances are recommended for minimum fabrication cost but can be decreased at added cost**

| Dimension (in.) | Recommended Tolerances (in.) | | | | | |
|---|---|---|---|---|---|---|
| | OD | ID | Length | Radius | Centerline of Radius | Step Dimension |
| To 1 | ±0.002 | ±0.002 | ±0.005 | ±0.010 | ±0.010 | 0.020 x 0.020 |
| 1 to 2 | ±0.002 | ±0.002 | ±0.005 | ±0.010 | ±0.010 | 0.030 x 0.030 |
| 2 to 3 | ±0.002 | ±0.002 | ±0.005 | ±0.010 | ±0.010 | 0.030 x 0.030 |
| 3 to 4 | ±0.002 | ±0.003 | ±0.005 | ± 1/32 | ± 1/32 | 0.040 x 0.040 |
| 4 to 5 | ±0.002 | ±0.003 | ±0.005 | ± 1/32 | ± 1/32 | ¼ flat on entrance end |
| 5 to 10 | ±0.004 | ±0.005 | ±0.010 | ± 1/32 | ± 1/16 | As above |
| 10 to 15 | ±0.004 | ±0.010 | ±0.010 | ± 1/16 | ± 1/8 | As above |
| 15 to 20 | ±0.004 | ±0.010 | ±0.010 | ± 1/16 | ± 1/8 | As above |
| Over 20 | ±0.004 | ±0.010 | ± 1/32 | ± 1/16 | ± 1/8 | As above |



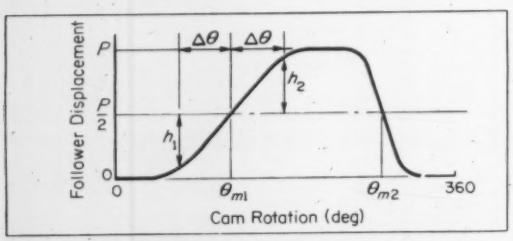

**1** Complementary cams with oscillating follower; equal-length arms in mid-position.

**How to increase accuracy in a complementary cam system by designing both cams for back-to-back machining.**

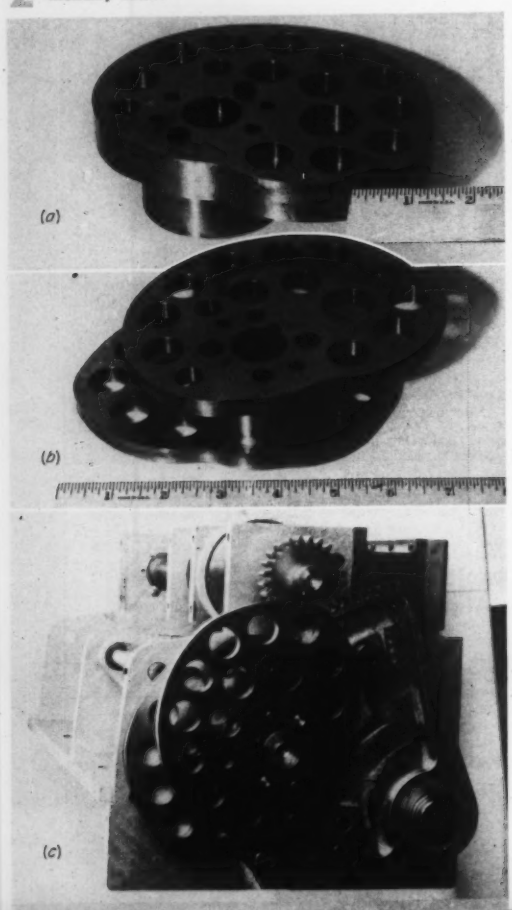
# Mirror-Image Cams

**By DAVID C. ALLAIS**

Associate Engineer
Research Laboratory
International Business Machines Corp.
San Jose, Calif.




**2** Preferred type of profile for single-contour complementary cams.




**3** Method of manufacturing the cams:
*a*—Cams are milled in one setup taking cuts each 1/4 degree to nearest 0.0001 in. Dowel-pin holes are bored on the fold line.
*b*—Cams are inverted and pinned with 3/8-in. dowel pins.
*c*—In actual installation, cams operate with maximum backlash of 0.001 in.

COMPLEMENTARY cam systems are generally superior to systems using spring-loaded followers, especially in high-speed mechanisms where transient dynamic loads result in poor follower action.

Conjugate cams generally require two contours but, in some cases, a single contour can be used for both the active and complementary cam if the follower translates radially or oscillates. For example, a single contour can be used for a dwell-rise-dwell-fall profile where the dwells are of equal duration. The rise and fall are independent and need only be symmetrical curves like the cycloid or balanced trapezoid.

The single-contour system permits both cams, placed back to back, to be generated simultaneously on an ordinary milling machine. After using the same setup to bore the locating holes on the fold line, the complementary cam is then reversed and pinned to the active cam through the fold holes.

In Fig. 1, angle $\theta_{mc}$ is often referred to as the corrected cam angle and will usually be different from the cam rotation, $\theta_m$, *Fig.* 2. Although the cam angle $\phi$ between the two followers will vary with a change of follower position, $\phi_m$ occurs when the followers are at midtravel.

In Fig. 2, $\theta_{m1}$ and $\theta_{m2}$ are the angles of cam rotation at which the follower is midway between its extreme positions. For the complementary cam to be a mirror image of the active cam, $h_1$ must equal $h_2$ for all values of $\Delta\theta$.

For an oscillating follower, the fold holes are located at $\theta_{mc} + \frac{1}{2}\,\phi_m$, and 180 degrees away from this position. The fold holes for a radial translating follower are located at $\theta_{m1} \pm 90$ degrees.

*A motor that can be stalled for short or long periods of time . . .*

*and can also work at any speed within its range . . .*

# THE TORQUE MOTOR

*will do these jobs:*

| | | |
|---|---|---|
| **hold position** | **brake** | **tighten** |
| **traverse** | **wind** | |
| **index** | **control** | **lock** |
| | **clamp** | |

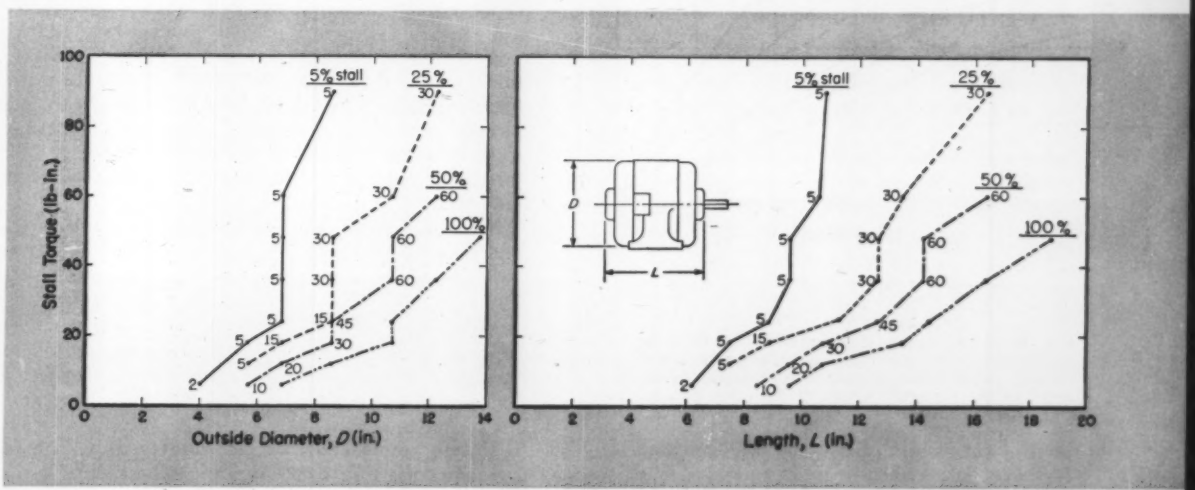
**By S. NOODLEMAN**
Vice President
B. A. Wesche Electric Co.
Cincinnati, Ohio

CONTINUOUS stalled operation is one of the unique possibilities offered by the torque motor. Or it can be used for any degree of cycling at the stalled or near-stalled condition. It works from zero speed, supplying torque only, to speeds close to its synchronous speed rating. Throughout this varying speed range it supplies both torque and speed.

Although it is not by itself a variable-speed ac motor, it is a variable-torque motor in that its torque can be easily controlled from a small percentage of its torque value up to rated torque.

In contrast, the standard induction motor can be stalled only for a very short time without causing

Fig. 1—Effects of stall torque on typical torque-motor frame dimensions. Curves are for 900-rpm, synchronous-speed torque motors and are based on one start and one coast-to-stop per cycle. For a plug-stop or plug-reverse, the torque rating must be reduced for a given frame size. Numbers at points along the curves indicate the approximate maximum time in minutes permissible for one stall period. If longer stall is required, a motor with higher duty rating or lower synchronous speed must be used



damage to the windings. Also, it provides power at a speed which is essentially constant and not readily changed.

The torque motor is not usually rated in horsepower but is instead stamped with values of torque and current for the stalled condition. When horsepower is shown on the nameplate, it is related to a certain speed; generally, for both horsepower and speed the given values are "nonstandard."

The design of a torque motor depends upon the duty cycle. Period or degree of stalling affects the amount of heat generated in the motor. Hence, physical size of the motor is determined largely by this factor and by the allowable temperature rise and the method of dissipating heat. Locked-rotor currents existing for any length of time practically demand forced cooling, if size and weight are to be held within reasonable limits.

Need for a reversible motor that must provide torque in both directions of rotation, or type of power supply, whether dc or single or polyphase ac, presents in each case its own design requirements.

Although torque motors are nonstandard, they are housed, by and large, in standard frames. Fig. 1 shows a representative progression of frame dimensions for various torque and stall conditions. Theoretical curves, of course, would be "smooth."

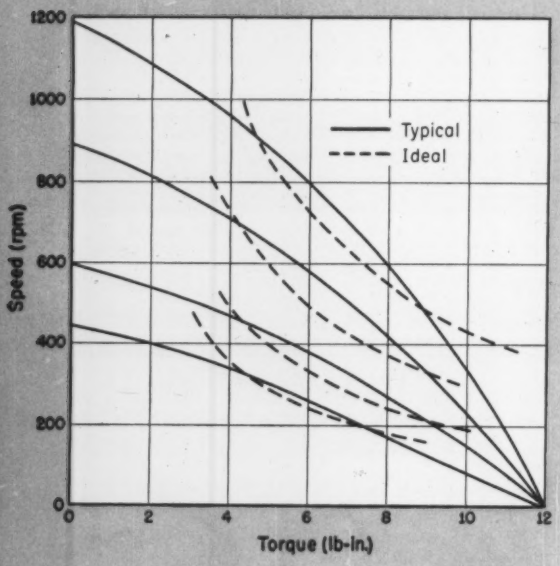



**Fig. 2—Speed-torque characteristics of 60-cycle torque motors for winding duty. The ideal curves indicate either constant tension or constant linear speed of the material, assuming the other parameter is held constant**

In some circumstances, packaging the right amount of iron and copper and taking care of the heat problem may lead to motors of special proportions—large diameter and short length, or vice versa.

Manufacturer's data, such as those on which Fig. 1 is based, provide a basis for selecting a motor to match the duty cycle. Chief criteria are maximum torque, synchronous speed, and time stalled. Also helpful are indications of maximum allowable stall periods, shown along the curves in Fig. 1.

For example, assume that for a 2-hr duty cycle a motor is selected with these ratings: Continuous stall period of 60 min and 50 per cent stall time. The motor would perform satisfactorily if the duty cycle were comprised of 60 min stall and 60 min (50 per cent) running (or cut off).

One might easily think that this same motor would be satisfactory for a cycle such as 55 min stall, 5 min cool, 55 min stall, and 105 min cool. After all, no stall period is as long as the allowed 60 min, and the motor is stalled for only 50 per cent of the longer 220 min cycle. However, the motor is being allowed to cool for only 5 min between two 55-min stall periods. Sufficient motor cooling in this cycle would probably require a motor with the next higher duty rating.

The torque motor with 5 per cent allowable stall time and a 5-min maximum continuous stall has a relatively small amount of iron and copper that quickly reaches its temperature limit. The thermal lag of larger motors allows them more time at stalled condition, but also requires a longer cooling period between extended stall operations. The motor designed for 100 per cent stall time, or continuous stalled operation, requires the largest frame dimensions for proper heat dissipation.

Torque motors are available in a wide range of synchronous speed ratings, such as 450, 600, 900, 1200, 1800 rpm. Also, for each synchronous speed, motors can be selected from an extended progression of torque capacities. Since wattage loss, and consequently heating, are reduced as synchronous speed decreases, selection of the lowest possible synchronous speed for the job becomes quite important.

Nearly all types of torque motors conform to the usual mechanical requirements associated with standard motors. The conventional squirrel-cage induction-motor construction is used for most applications. Torque motors are readily available with double-shaft construction, totally enclosed or explosion-proof construction, or shell-type shaftless-rotor construction, and with any of the special features required for operation at high humidity, high temperature, or severe vibration.

Winding, rapid traversing, indexing, clamping, and holding are kinds of service to which the torque motor is ideally suited.

**Winding:** Ability to maintain either constant tension or constant speed makes the torque motor especially suited to winding operations. As material builds up in the reel, the motor slows down and the torque increases.

When motors are used for winding duty, one of the two following conditions must be met:

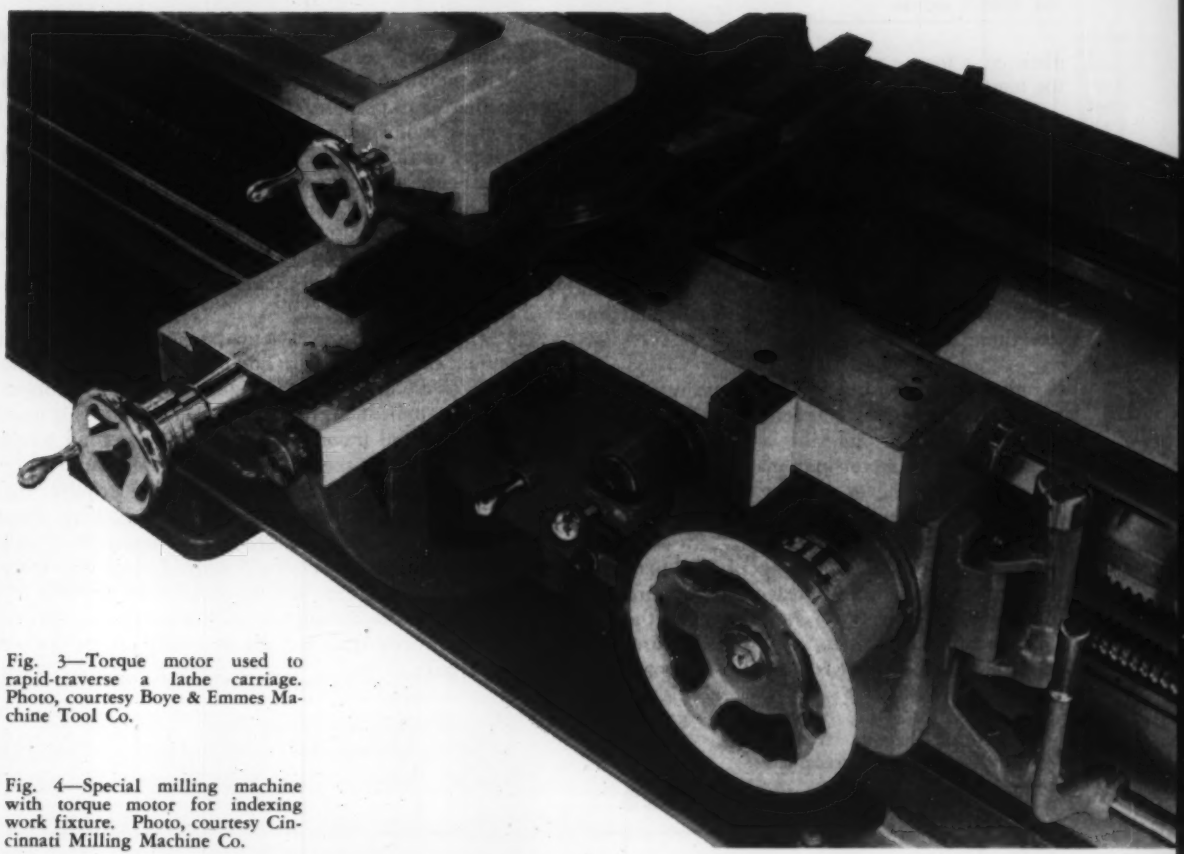
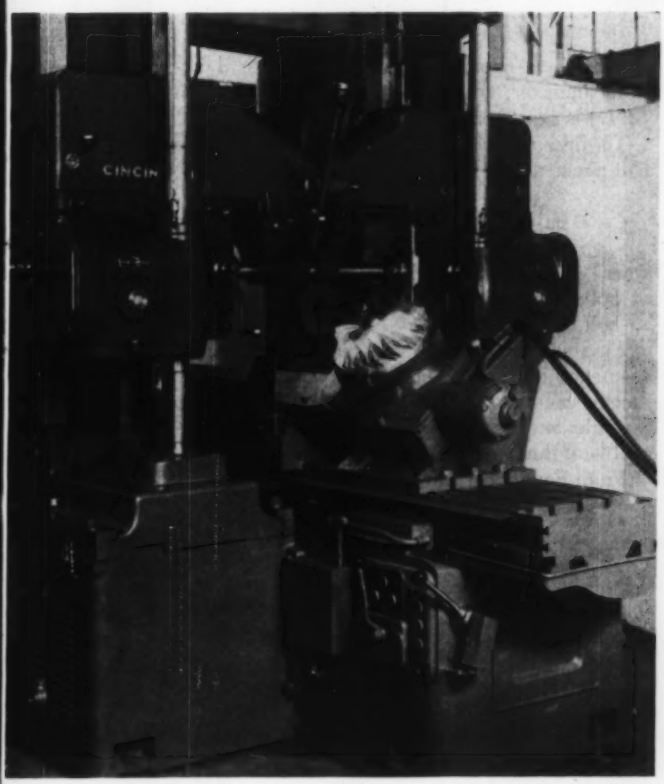


Fig. 3—Torque motor used to rapid-traverse a lathe carriage. Photo, courtesy Boye & Emmes Machine Tool Co.

Fig. 4—Special milling machine with torque motor for indexing work fixture. Photo, courtesy Cincinnati Milling Machine Co.




1. If the material is fed to the final take-up motor at constant linear speed, the motor must maintain constant tension throughout the range of build-up of material on the reel.
2. If the material is fed to the final take-up motor under constant tension, the take-up motor must maintain constant linear speed of the material.

A series of actual speed-torque characteristics for winding-duty torque motors is shown in Fig. 2. Throughout approximately a 2 to 1 range of build-up of material, the motor essentially maintains the required conditions.

Selection of a torque motor for a specific winding operation must be based on the particular duty cycle. However, most winding operations are likely to fall within a certain duty range.

At the one extreme are those uses which require that the motor operate from about 2/3 synchronous speed to almost stalled condition for short periods. Motors rated at about 50 per cent stall duty match this kind of service.

At the other extreme, very severe duty occurs, for example, when the motor is stalled while holding the material in tension during a part of the winding operation. Such service may require a continuous stalled duty motor.

**Rapid Traversing:** When components must be moved quickly back and forth along a track or guide, or between any two positions in the total

distance, a torque motor can be used to save time in the machine cycle.

Fig. 3 shows a motor fastened to the carriage of a lathe for rapidly traversing the carriage from one end of the lathe to the other. In such cases a brake can be fitted to one end of the motor so that the carriage can be stopped and accurately positioned, also.

Service of this type generally requires motors in only the 10 to 25 per cent duty class. Consequently, high torques are available in relatively small frames for these applications.

**Indexing:** For positioning and indexing, the torque motor need not operate as long or as fast as in rapid traversing. When indexing a part for machining or assembly, the motor may make only a few revolutions and often never reaches a constant speed before it is required to stop.

The rise-and-fall miller, Fig. 4, uses a torque motor for automatic indexing of the fixture. On this machine the motor drives the fixture past a limit switch, then is reversed to drive the fixture home against a positive stop. The fixture is then clamped and the motor is disconnected from the line.

**Clamping:** Torque motors for clamping or locking action may turn only a fraction of a revolution. The motor torque mechanically locks the parts together or in position. For example, on machine tools torque motors are often used to lock moving carriages or rails to the machine frame through switch and lever arrangements.

Since in such clamping applications the motor is energized for only a very short time, the duty cycle can be considered as instantaneous. Hence, for some cases, a 5 per cent duty rating may be sufficient.

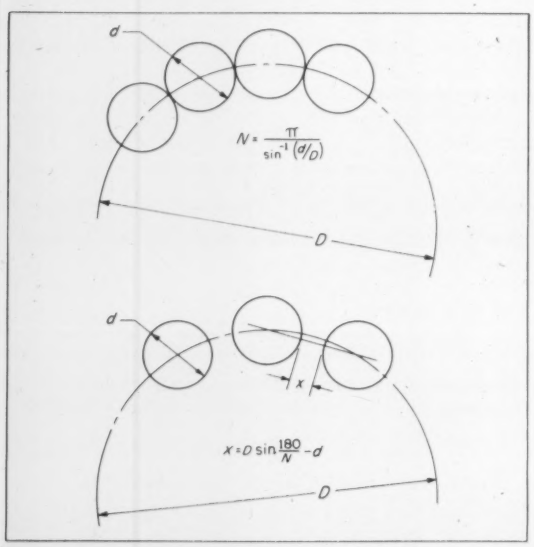
**Holding:** Serving as a magnetic spring, a torque motor can be used for holding or supporting a device, or merely counteracting the weight of an object. In one application, for example, apparatus is stopped in its vertical travel and held while a second torque motor positions the equipment on a horizontal plane.

Certain holding applications may require that the torque motor be energized continuously under stalled conditions. However, for economy, the torque motor should be energized only during the operation of the system and a brake used to hold the weight at the completion of the operation. Reduction in required motor size generally offsets the cost of a brake.

# Tips and Techniques

## *Bolt Clearance*

In design of pressure vessels or other structures which use circular bolt arrangements, a critical question is how many bolts will fit on a specified bolt circle, and also what the clearance between bolt heads will be. To find the maximum number of bolt heads that will fit on a certain bolt circle, use




$$N = \frac{\pi}{\sin^{-1}(d/D)} \qquad (1)$$

where $N$ = maximum number of bolts; $d$ = bolt head diameter; and $D$ = bolt circle diameter. $\text{Sin}^{-1}(d/D)$ is expressed in radians.

To find the clearance between bolt heads on a bolt circle, use

$$X = D \sin \frac{180}{n} - d \qquad (2)$$

where $X$ = clearance between heads; $n$ = number of bolts required; $d$ = bolt head diameter; and $D$ = bolt circle diameter.

EXAMPLE: Eighteen socket-head bolts with head diameters of 9/16 in. are required on a 3⅝-in. diameter bolt circle. Determine if this arrangement is possible, and if so, what the clearance between heads will be if the bolts are evenly spaced.

From Equation 1,

$$N = \frac{\pi}{\sin^{-1}\dfrac{0.5625}{3.625}} = 20.2$$

Thus, 18 bolts will fit on the circle. Clearance between the 18 bolt heads from Equation 2 is

$$X = 3.625 \sin \frac{180}{18} - 0.5625 = 0.066 \text{ in.}$$

—JOHN R. SMITH, *Westinghouse Electric Corp., Pittsburgh 30, Pa.*

# *Four-Bar Linkages*

# POINT—POSITION REDUCTION

*. . . a design method for satisfying input-output position specifications*

**By C. WESLEY ALLEN**
Engineer
General Electric Co.
Richland, Wash.

FOUR-BAR linkages which require correlations between input and output crank positions can be designed in many ways. The point-position reduction* method presented here permits the construction of a linkage that satisfies design requirements exactly, at a limited number of positions. It should be noted that although this method gives exact positions required, it does not limit the maximum error away from the design positions. Although this discussion is limited to four-link mechanisms, a greater number of exact positions can be obtained by using more links.

**Three Positions:** This simple case does not involve the principle of point-position reduction, but is included to illustrate the construction principle used in all point-position reduction problems.

DESIGN PROCEDURE: It is desired that input crank $A_oA$, Fig. 1, should move clockwise through three given positions while an output crank $B_oB$, moves counterclockwise through three related positions. In this analysis, input crank and $A_oB_o$ lengths are selected, angles $\phi_{12}$, $\phi_{23}$, $\Psi_{12}$, $\Psi_{23}$, and location of the initial position of the input crank with respect to the fixed axis are given, and output crank and coupler lengths are to be found.

1. Lay out lines $A_oB_o$, $A_oA_1$, $A_oA_2$, and $A_oA_3$ in their proper relative positions.
2. Using the inversion of the linkage in which the output crank is fixed in the first position, rotate line $A_oB_o$ and each of the $A_oA$ lines so that they assume their correct relative position for each of the positions. Point $A_1'$ falls at point $A_1$. To obtain $A_2'$, pivot line $A_oB_o$ about $B_o$ by $\psi_{12}$ in the direction opposite to the desired rotation of the output crank. During the preceding operation the position of $A_oA_2$ relative to $A_oB_o$ is held constant. A similar procedure locates $A_3'$.
3. $B_1$ is now the center of a circle passing through $A_1'$, $A_2'$, and $A_3'$. To find $B_1$, draw the perpendicular bisector of lines $A_1'$ $A_2'$ and $A_2'$ $A_3'$. Intersection of the two perpendicular bisectors is point $B_1$. Line $A_1$ $B_1$ is the length of the coupler, and line $B_oB_1$ is the length of the output crank. Drawing in lines $A_1B_1$ and $B_oB_1$ completes the mechanism in the first position. The other positions are obtained by laying out $B_oB$ in its other two positions with respect to $B_oB_1$ and drawing in lines $A_2B_2$ and $A_3B_3$.

**Four Positions:** Analysis of the preceding procedure shows that this construction works whenever there are three $A'$ points. It is the principle of point-position reduction that reduces the number of $A'$ points to three. Since there are four design positions, there are six angles. Also, the length of $A_oA$ is chosen, but the choice of this length has no effect on the final design except to determine the over-all size. To assure the existence of only

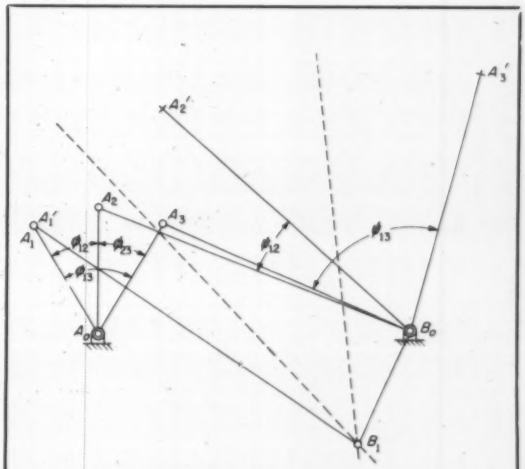



Fig. 1—Three-position design of four-bar linkage

*K. Hain — *Angewandte Getriebelehre*, Hannover - Darmstadt, Shrodel, 1952.

## Table 1—Values of $K$ for $R = 2$

| $A_oB_o/A_oA$ | Input Range, $\phi_{15}$ (deg) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 180 | 170 | 160 | 150 | 140 | 130 | 120 | 110 | 100 | 90 | 80 | 70 | 60 | 50 | 40 |
| 5.0 | .8270 | .7857 | .7485 | .7151 | .6849 | .6577 | .6331 | .6110 | .5911 | .5734 | .5578 | .5441 | .5323 | .5224 | .5143 |
| 4.9 | .8299 | .7883 | .7509 | .7172 | .6868 | .6593 | .6345 | .6122 | .5922 | .5743 | .5585 | .5446 | .5327 | .5227 | .5145 |
| 4.8 | .8329 | .7910 | .7534 | .7195 | .6888 | .6611 | .6361 | .6136 | .5933 | .5752 | .5592 | .5452 | .5332 | .5230 | .5147 |
| 4.7 | .8361 | .7939 | .7560 | .7218 | .6909 | .6630 | .6377 | .6150 | .5945 | .5762 | .5600 | .5459 | .5336 | .5233 | .5149 |
| 4.6 | .8394 | .7970 | .7588 | .7243 | .6931 | .6650 | .6395 | .6165 | .5958 | .5773 | .5609 | .5465 | .5341 | .5237 | .5151 |
| 4.5 | .8429 | .8002 | .7617 | .7269 | .6955 | .6670 | .6413 | .6180 | .5971 | .5784 | .5618 | .5472 | .5347 | .5241 | .5154 |
| 4.4 | .8466 | .8035 | .7647 | .7297 | .6980 | .6692 | .6432 | .6197 | .5985 | .5796 | .5627 | .5480 | .5352 | .5245 | .5156 |
| 4.3 | .8504 | .8071 | .7680 | .7326 | .7006 | .6716 | .6453 | .6215 | .6000 | .5808 | .5638 | .5488 | .5358 | .5249 | .5159 |
| 4.2 | .8545 | .8108 | .7714 | .7357 | .7034 | .6741 | .6474 | .6234 | .6016 | .5822 | .5648 | .5496 | .5365 | .5253 | .5162 |
| 4.1 | .8589 | .8148 | .7750 | .7390 | .7064 | .6767 | .6498 | .6254 | .6034 | .5836 | .5660 | .5505 | .5371 | .5258 | .5165 |
| 4.0 | .8634 | .8190 | .7789 | .7425 | .7095 | .6795 | .6522 | .6275 | .6052 | .5851 | .5673 | .5515 | .5379 | .5263 | .5169 |
| 3.9 | .8683 | .8235 | .7830 | .7462 | .7129 | .6825 | .6549 | .6298 | .6071 | .5868 | .5686 | .5526 | .5387 | .5269 | .5172 |
| 3.8 | .8735 | .8282 | .7873 | .7502 | .7164 | .6857 | .6577 | .6323 | .6093 | .5885 | .5700 | .5537 | .5395 | .5275 | .5176 |
| 3.7 | .8789 | .8333 | .7920 | .7544 | .7203 | .6891 | .6607 | .6349 | .6115 | .5904 | .5716 | .5549 | .5405 | .5281 | .5181 |
| 3.6 | .8848 | .8387 | .7969 | .7590 | .7244 | .6928 | .6640 | .6378 | .6140 | .5925 | .5733 | .5563 | .5415 | .5289 | .5185 |
| 3.5 | .8910 | .8445 | .8022 | .7638 | .7288 | .6968 | .6675 | .6408 | .6166 | .5947 | .5751 | .5577 | .5426 | .5297 | .5191 |
| 3.4 | .8977 | .8506 | .8080 | .7691 | .7335 | .7010 | .6713 | .6442 | .6195 | .5971 | .5771 | .5593 | .5438 | .5305 | .5196 |
| 3.3 | .9048 | .8573 | .8141 | .7747 | .7387 | .7057 | .6754 | .6478 | .6226 | .5998 | .5793 | .5610 | .5451 | .5315 | .5202 |
| 3.2 | .9125 | .8644 | .8207 | .7807 | .7442 | .7107 | .6799 | .6518 | .6260 | .6027 | .5816 | .5629 | .5465 | .5325 | .5209 |
| 3.1 | .9208 | .8721 | .8279 | .7874 | .7502 | .7161 | .6848 | .6561 | .6298 | .6058 | .5843 | .5650 | .5481 | .5337 | .5217 |
| 3.0 | .9297 | .8805 | .8356 | .7945 | .7568 | .7221 | .6902 | .6608 | .6339 | .6094 | .5872 | .5673 | .5499 | .5349 | .5225 |
| 2.9 | .9394 | .8895 | .8440 | .8023 | .7640 | .7286 | .6961 | .6660 | .6384 | .6132 | .5904 | .5699 | .5519 | .5364 | .5235 |
| 2.8 | .9498 | .8994 | .8532 | .8109 | .7719 | .7358 | .7025 | .6718 | .6435 | .6176 | .5940 | .5728 | .5541 | .5380 | .5245 |
| 2.7 | .9612 | .9101 | .8633 | .8203 | .7805 | .7438 | .7097 | .6782 | .6491 | .6224 | .5981 | .5761 | .5567 | .5398 | .5258 |
| 2.6 | .9737 | .9218 | .8743 | .8306 | .7901 | .7526 | .7177 | .6854 | .6555 | .6279 | .6026 | .5798 | .5595 | .5419 | .5272 |
| 2.5 | .9873 | .9347 | .8865 | .8420 | .8007 | .7624 | .7267 | .6935 | .6626 | .6341 | .6079 | .5841 | .5628 | .5444 | .5288 |
| 2.4 | .9997 | .9489 | .8999 | .8547 | .8126 | .7734 | .7368 | .7026 | .6707 | .6411 | .6138 | .5890 | .5669 | .5472 | .5307 |
| 2.3 | .9972 | .9646 | .9149 | .8688 | .8258 | .7857 | .7482 | .7129 | .6800 | .6492 | .6208 | .5947 | .5712 | .5505 | .5329 |
| 2.2 | .9942 | .9821 | .9315 | .8846 | .8408 | .7997 | .7611 | .7248 | .6907 | .6586 | .6288 | .6014 | .5765 | .5544 | .5356 |
| 2.1 | .9906 | .9997 | .9502 | .9024 | .8577 | .8157 | .7760 | .7385 | .7031 | .6697 | .6384 | .6093 | .5828 | .5592 | .5389 |
| 2.0 | .9863 | .9958 | .9711 | .9225 | .8769 | .8339 | .7931 | .7544 | .7176 | .6827 | .6497 | .6189 | .5906 | .5651 | .5429 |
| 1.9 | .9810 | .9909 | .9948 | .9454 | .8989 | .8549 | .8131 | .7731 | .7348 | .6983 | .6635 | .6307 | .6001 | .5724 | .5480 |
| 1.8 | .9745 | .9849 | .9955 | .9715 | .9243 | .8794 | .8364 | .7952 | .7554 | .7171 | .6803 | .6452 | .6121 | .5817 | .5546 |
| 1.7 | .9666 | .9774 | .9884 | .9997 | .9535 | .9078 | .8639 | .8215 | .7803 | .7402 | .7013 | .6636 | .6276 | .5939 | .5635 |
| 1.6 | .9569 | .9680 | .9794 | .9911 | .9875 | .9413 | .8966 | .8532 | .8107 | .7690 | .7278 | .6874 | .6480 | .6104 | .5756 |
| 1.5 | .9451 | .9562 | .9678 | .9799 | .9925 | .9806 | .9357 | .8917 | .8483 | .8051 | .7619 | .7188 | .6757 | .6335 | .5932 |
| 1.4 | .9305 | .9415 | .9531 | .9653 | .9781 | .9916 | .9822 | .9384 | .8948 | .8510 | .8065 | .7610 | .7145 | .6671 | .6199 |
| 1.3 | .9126 | .9231 | .9343 | .9462 | .9589 | .9723 | .9866 | .9950 | .9525 | .9095 | .8653 | .8190 | .7701 | .7180 | .6631 |
| 1.2 | .8908 | .9004 | .9107 | .9217 | .9334 | .9460 | .9596 | .9743 | .9902 | .9831 | .9419 | .8984 | .8510 | .7980 | .7378 |
| 1.1 | .8645 | .8727 | .8815 | .8908 | .9007 | .9113 | .9227 | .9351 | .9486 | .9635 | .9801 | .9987 | .9645 | .9216 | .8698 |
| 1.0 | .8333 | .8396 | .8462 | .8529 | .8600 | .8673 | .8750 | .8830 | .8913 | .9000 | .9091 | .9186 | .9286 | .9390 | .9500 |
| 0.9 | .7975 | .8013 | .8051 | .8087 | .8121 | .8152 | .8179 | .8200 | .8212 | .8211 | .8193 | .8148 | .8064 | .7918 | .7672 |
| 0.8 | .7577 | .7589 | .7596 | .7599 | .7595 | .7582 | .7559 | .7523 | .7469 | .7392 | .7287 | .7143 | .6952 | .6700 | .6376 |
| 0.7 | .7154 | .7142 | .7123 | .7096 | .7060 | .7014 | .6954 | .6880 | .6787 | .6673 | .6534 | .6369 | .6174 | .5951 | .5706 |
| 0.6 | .6728 | .6697 | .6659 | .6613 | .6558 | .6493 | .6418 | .6330 | .6229 | .6114 | .5985 | .5843 | .5690 | .5532 | .5374 |
| 0.5 | .6321 | .6279 | .6232 | .6179 | .6119 | .6052 | .5977 | .5895 | .5806 | .5711 | .5610 | .5506 | .5401 | .5298 | .5203 |
| 0.4 | .5950 | .5908 | .5861 | .5811 | .5757 | .5698 | .5636 | .5571 | .5503 | .5434 | .5364 | .5294 | .5227 | .5165 | .5110 |
| 0.3 | .5630 | .5593 | .5555 | .5515 | .5472 | .5429 | .5384 | .5339 | .5293 | .5248 | .5204 | .5162 | .5123 | .5088 | .5058 |
| 0.2 | .5365 | .5339 | .5313 | .5286 | .5259 | .5232 | .5204 | .5178 | .5151 | .5126 | .5103 | .5080 | .5060 | .5043 | .5028 |
| 0.1 | .5156 | .5144 | .5131 | .5118 | .5105 | .5093 | .5081 | .5070 | .5059 | .5048 | .5039 | .5030 | .5022 | .5016 | .5010 |

## Table 2—Values of $K$ for $R = 3$

| $A_oB_o/A_oA$ | Input Range, $\phi_{15}$ (deg) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 180 | 170 | 160 | 150 | 140 | 130 | 120 | 110 | 100 | 90 | 80 | 70 | 60 | 50 | 40 |
| 5.0 | .6098 | .5733 | .5408 | .5119 | .4859 | .4627 | .4420 | .4235 | .4070 | .3925 | .3797 | .3686 | .3591 | .3511 | .3447 |
| 4.9 | .6126 | .5758 | .5430 | .5138 | .4876 | .4642 | .4433 | .4246 | .4079 | .3932 | .3803 | .3690 | .3594 | .3514 | .3448 |
| 4.8 | .6155 | .5784 | .5454 | .5159 | .4895 | .4658 | .4446 | .4257 | .4089 | .3940 | .3809 | .3695 | .3598 | .3516 | .3450 |
| 4.7 | .6186 | .5812 | .5478 | .5180 | .4914 | .4675 | .4461 | .4269 | .4100 | .3948 | .3816 | .3700 | .3602 | .3519 | .3452 |
| 4.6 | .6219 | .5841 | .5504 | .5203 | .4934 | .4692 | .4476 | .4282 | .4110 | .3957 | .3823 | .3706 | .3606 | .3522 | .3454 |
| 4.5 | .6253 | .5872 | .5532 | .5228 | .4955 | .4711 | .4492 | .4296 | .4121 | .3966 | .3830 | .3712 | .3610 | .3525 | .3455 |
| 4.4 | .6289 | .5904 | .5561 | .5253 | .4978 | .4730 | .4509 | .4310 | .4133 | .3976 | .3838 | .3718 | .3614 | .3528 | .3458 |
| 4.3 | .6328 | .5939 | .5592 | .5281 | .5002 | .4751 | .4527 | .4326 | .4146 | .3987 | .3846 | .3724 | .3619 | .3531 | .3460 |
| 4.2 | .6369 | .5975 | .5624 | .5310 | .5027 | .4774 | .4546 | .4342 | .4160 | .3998 | .3856 | .3731 | .3625 | .3535 | .3462 |
| 4.1 | .6412 | .6014 | .5659 | .5340 | .5054 | .4797 | .4566 | .4359 | .4175 | .4010 | .3865 | .3739 | .3630 | .3539 | .3465 |
| 4.0 | .6458 | .6056 | .5696 | .5373 | .5083 | .4823 | .4588 | .4378 | .4190 | .4023 | .3876 | .3747 | .3636 | .3543 | .3467 |
| 3.9 | .6507 | .6100 | .5735 | .5408 | .5114 | .4850 | .4612 | .4398 | .4207 | .4037 | .3887 | .3756 | .3643 | .3548 | .3470 |
| 3.8 | .6560 | .6147 | .5778 | .5446 | .5148 | .4879 | .4637 | .4420 | .4225 | .4052 | .3899 | .3765 | .3650 | .3553 | .3474 |
| 3.7 | .6616 | .6198 | .5823 | .5486 | .5183 | .4910 | .4664 | .4443 | .4245 | .4068 | .3912 | .3775 | .3657 | .3558 | .3477 |
| 3.6 | .6676 | .6252 | .5872 | .5530 | .5222 | .4944 | .4694 | .4468 | .4266 | .4086 | .3926 | .3786 | .3665 | .3564 | .3481 |
| 3.5 | .6741 | .6310 | .5924 | .5577 | .5263 | .4981 | .4725 | .4495 | .4289 | .4105 | .3941 | .3798 | .3674 | .3570 | .3485 |
| 3.4 | .6811 | .6373 | .5981 | .5627 | .5308 | .5020 | .4760 | .4525 | .4314 | .4125 | .3958 | .3811 | .3684 | .3577 | .3489 |
| 3.3 | .6886 | .6441 | .6042 | .5682 | .5357 | .5063 | .4797 | .4557 | .4341 | .4148 | .3976 | .3825 | .3695 | .3585 | .3494 |
| 3.2 | .6968 | .6515 | .6109 | .5742 | .5411 | .5110 | .4838 | .4593 | .4371 | .4173 | .3997 | .3841 | .3707 | .3593 | .3500 |
| 3.1 | .7056 | .6596 | .6182 | .5807 | .5469 | .5162 | .4883 | .4632 | .4404 | .4200 | .4019 | .3859 | .3720 | .3602 | .3506 |
| 3.0 | .7153 | .6684 | .6261 | .5879 | .5533 | .5218 | .4933 | .4675 | .4441 | .4231 | .4044 | .3878 | .3735 | .3613 | .3513 |
| 2.9 | .7259 | .6780 | .6349 | .5958 | .5603 | .5281 | .4988 | .4722 | .4481 | .4265 | .4071 | .3900 | .3751 | .3625 | .3520 |
| 2.8 | .7375 | .6886 | .6445 | .6045 | .5681 | .5350 | .5049 | .4775 | .4527 | .4303 | .4102 | .3925 | .3770 | .3638 | .3529 |
| 2.7 | .7504 | .7004 | .6552 | .6141 | .5768 | .5428 | .5117 | .4834 | .4578 | .4345 | .4137 | .3952 | .3791 | .3653 | .3539 |
| 2.6 | .7646 | .7134 | .6670 | .6249 | .5865 | .5514 | .5194 | .4901 | .4635 | .4394 | .4177 | .3984 | .3815 | .3670 | .3550 |
| 2.5 | .7804 | .7279 | .6803 | .6370 | .5974 | .5612 | .5281 | .4977 | .4701 | .4449 | .4222 | .4020 | .3843 | .3690 | .3564 |
| 2.4 | .7981 | .7442 | .6953 | .6506 | .6098 | .5723 | .5379 | .5064 | .4776 | .4513 | .4275 | .4062 | .3875 | .3713 | .3579 |
| 2.3 | .8180 | .7626 | .7122 | .6661 | .6239 | .5850 | .5493 | .5164 | .4863 | .4587 | .4336 | .4112 | .3913 | .3741 | .3597 |
| 2.2 | .8406 | .7835 | .7315 | .6838 | .6400 | .5997 | .5624 | .5281 | .4964 | .4674 | .4409 | .4170 | .3958 | .3774 | .3619 |
| 2.1 | .8662 | .8074 | .7536 | .7043 | .6588 | .6167 | .5778 | .5417 | .5084 | .4777 | .4495 | .4240 | .4012 | .3814 | .3646 |
| 2.0 | .8957 | .8349 | .7793 | .7280 | .6807 | .6368 | .5959 | .5580 | .5227 | .4900 | .4600 | .4326 | .4079 | .3863 | .3679 |
| 1.9 | .9297 | .8669 | .8092 | .7559 | .7065 | .6605 | .6176 | .5775 | .5401 | .5052 | .4728 | .4432 | .4163 | .3925 | .3722 |
| 1.8 | .9693 | .9043 | .8444 | .7890 | .7374 | .6892 | .6439 | .6014 | .5614 | .5239 | .4890 | .4566 | .4270 | .4006 | .3777 |
| 1.7 | .9968 | .9484 | .8863 | .8286 | .7747 | .7240 | .6762 | .6310 | .5882 | .5477 | .5096 | .4740 | .4410 | .4112 | .3851 |
| 1.6 | .9847 | .9998 | .9367 | .8767 | .8203 | .7671 | .7166 | .6684 | .6225 | .5786 | .5368 | .4971 | .4600 | .4259 | .3956 |
| 1.5 | .9688 | .9844 | .9976 | .9354 | .8768 | .8211 | .7679 | .7167 | .6673 | .6196 | .5735 | .5292 | .4868 | .4471 | .4109 |
| 1.4 | .9475 | .9635 | .9803 | .9977 | .9474 | .8897 | .8341 | .7801 | .7275 | .6758 | .6251 | .5752 | .5264 | .4793 | .4351 |
| 1.3 | .9194 | .9352 | .9519 | .9695 | .9882 | .9773 | .9204 | .8648 | .8098 | .7550 | .7000 | .6444 | .5883 | .5320 | .4764 |
| 1.2 | .8826 | .8973 | .9129 | .9295 | .9474 | .9665 | .9870 | .9780 | .9235 | .8685 | .8121 | .7534 | .6915 | .6257 | .5560 |
| 1.1 | .8355 | .8478 | .8608 | .8746 | .8895 | .9056 | .9230 | .9420 | .9629 | .9859 | .9779 | .9259 | .8694 | .8055 | .7305 |
| 1.0 | .7778 | .7862 | .7949 | .8039 | .8133 | .8231 | .8333 | .8440 | .8551 | .8667 | .8788 | .8915 | .9048 | .9187 | .9334 |
| 0.9 | .7113 | .7150 | .7184 | .7214 | .7238 | .7256 | .7264 | .7259 | .7237 | .7193 | .7116 | .6996 | .6813 | .6542 | .6144 |
| 0.8 | .6411 | .6403 | .6387 | .6363 | .6327 | .6278 | .6213 | .6128 | .6019 | .5882 | .5710 | .5498 | .5240 | .4931 | .4573 |
| 0.7 | .5731 | .5692 | .5643 | .5585 | .5516 | .5434 | .5337 | .5225 | .5095 | .4945 | .4776 | .4587 | .4379 | .4157 | .3929 |
| 0.6 | .5124 | .5070 | .5009 | .4940 | .4862 | .4775 | .4679 | .4574 | .4458 | .4334 | .4201 | .4062 | .3918 | .3776 | .3639 |
| 0.5 | .4615 | .4560 | .4500 | .4434 | .4364 | .4289 | .4209 | .4124 | .4035 | .3943 | .3849 | .3755 | .3663 | .3576 | .3497 |
| 0.4 | .4205 | .4157 | .4107 | .4053 | .3998 | .3940 | .3880 | .3819 | .3757 | .3694 | .3633 | .3574 | .3518 | .3466 | .3421 |
| 0.3 | .3885 | .3849 | .3811 | .3773 | .3734 | .3694 | .3654 | .3614 | .3574 | .3536 | .3499 | .3464 | .3432 | .3404 | .3379 |
| 0.2 | .3642 | .3618 | .3595 | .3571 | .3547 | .3524 | .3500 | .3478 | .3456 | .3435 | .3416 | .3398 | .3381 | .3367 | .3355 |
| 0.1 | .3462 | .3451 | .3440 | .3429 | .3419 | .3408 | .3399 | .3389 | .3380 | .3372 | .3364 | .3357 | .3351 | .3346 | .3341 |

| | 180 | 170 | 160 | 150 | 140 | 130 | 120 | 110 | 100 | 90 | 80 | 70 | 60 | 50 | 40 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| −0.0 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 |
| −0.1 | .4890 | .4902 | .4912 | .4923 | .4932 | .4941 | .4950 | .4958 | .4965 | .4972 | .4977 | .4983 | .4987 | .4991 | .4994 |
| −0.2 | .4821 | .4841 | .4860 | .4877 | .4893 | .4908 | .4922 | .4935 | .4946 | .4957 | .4966 | .4974 | .4981 | .4987 | .4992 |
| −0.3 | .4785 | .4810 | .4834 | .4855 | .4875 | .4894 | .4910 | .4925 | .4939 | .4951 | .4961 | .4970 | .4978 | .4985 | .4990 |
| −0.4 | .4775 | .4803 | .4829 | .4852 | .4873 | .4892 | .4909 | .4925 | .4939 | .4951 | .4961 | .4971 | .4979 | .4985 | .4991 |
| −0.5 | .4786 | .4814 | .4839 | .4862 | .4882 | .4900 | .4916 | .4931 | .4943 | .4955 | .4965 | .4973 | .4981 | .4987 | .4991 |
| −0.6 | .4813 | .4838 | .4860 | .4880 | .4898 | .4914 | .4928 | .4941 | .4952 | .4962 | .4970 | .4977 | .4983 | .4989 | .4993 |
| −0.7 | .4850 | .4871 | .4889 | .4905 | .4920 | .4932 | .4944 | .4954 | .4962 | .4970 | .4977 | .4982 | .4987 | .4991 | .4994 |
| −0.8 | .4896 | .4910 | .4923 | .4935 | .4945 | .4954 | .4961 | .4968 | .4974 | .4980 | .4984 | .4988 | .4991 | .4994 | .4996 |
| −0.9 | .4946 | .4954 | .4961 | .4967 | .4972 | .4976 | .4980 | .4984 | .4987 | .4990 | .4992 | .4994 | .4996 | .4997 | .4998 |
| −1.0 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 |
| −1.1 | .5055 | .5047 | .5040 | .5034 | .5029 | .5024 | .5020 | .5016 | .5013 | .5010 | .5008 | .5006 | .5004 | .5003 | .5002 |
| −1.2 | .5111 | .5094 | .5080 | .5068 | .5057 | .5048 | .5040 | .5032 | .5026 | .5021 | .5016 | .5012 | .5009 | .5006 | .5004 |
| −1.3 | .5166 | .5141 | .5120 | .5101 | .5085 | .5071 | .5059 | .5048 | .5039 | .5031 | .5024 | .5018 | .5013 | .5009 | .5006 |
| −1.4 | .5220 | .5187 | .5159 | .5134 | .5113 | .5094 | .5078 | .5064 | .5052 | .5041 | .5032 | .5024 | .5017 | .5012 | .5008 |
| −1.5 | .5273 | .5232 | .5197 | .5166 | .5140 | .5117 | .5096 | .5079 | .5064 | .5050 | .5039 | .5029 | .5021 | .5015 | .5009 |
| −1.6 | .5324 | .5275 | .5234 | .5197 | .5166 | .5138 | .5114 | .5094 | .5075 | .5060 | .5046 | .5035 | .5025 | .5017 | .5011 |
| −1.7 | .5373 | .5317 | .5269 | .5227 | .5191 | .5159 | .5132 | .5108 | .5087 | .5069 | .5053 | .5040 | .5029 | .5020 | .5013 |
| −1.8 | .5421 | .5358 | .5303 | .5256 | .5215 | .5179 | .5148 | .5121 | .5098 | .5077 | .5060 | .5045 | .5033 | .5022 | .5014 |
| −1.9 | .5467 | .5397 | .5336 | .5284 | .5238 | .5199 | .5164 | .5134 | .5108 | .5086 | .5066 | .5050 | .5036 | .5025 | .5016 |
| −2.0 | .5511 | .5434 | .5367 | .5310 | .5260 | .5217 | .5179 | .5147 | .5118 | .5094 | .5073 | .5055 | .5040 | .5027 | .5017 |
| −2.1 | .5553 | .5469 | .5398 | .5336 | .5282 | .5235 | .5194 | .5159 | .5128 | .5101 | .5079 | .5059 | .5043 | .5029 | .5019 |
| −2.2 | .5593 | .5504 | .5427 | .5360 | .5302 | .5252 | .5208 | .5170 | .5137 | .5109 | .5084 | .5063 | .5046 | .5032 | .5020 |
| −2.3 | .5631 | .5536 | .5454 | .5383 | .5322 | .5268 | .5222 | .5181 | .5146 | .5116 | .5090 | .5068 | .5049 | .5034 | .5021 |
| −2.4 | .5668 | .5567 | .5481 | .5406 | .5341 | .5284 | .5235 | .5192 | .5155 | .5123 | .5095 | .5072 | .5052 | .5036 | .5023 |
| −2.5 | .5703 | .5597 | .5506 | .5427 | .5359 | .5299 | .5247 | .5202 | .5163 | .5129 | .5100 | .5075 | .5055 | .5037 | .5024 |
| −2.6 | .5737 | .5626 | .5531 | .5448 | .5376 | .5314 | .5259 | .5212 | .5171 | .5135 | .5105 | .5079 | .5057 | .5039 | .5025 |
| −2.7 | .5769 | .5654 | .5554 | .5468 | .5393 | .5327 | .5271 | .5221 | .5178 | .5141 | .5110 | .5083 | .5060 | .5041 | .5026 |
| −2.8 | .5800 | .5680 | .5576 | .5487 | .5409 | .5341 | .5282 | .5230 | .5186 | .5147 | .5114 | .5086 | .5062 | .5043 | .5027 |
| −2.9 | .5830 | .5705 | .5598 | .5505 | .5424 | .5354 | .5292 | .5239 | .5193 | .5153 | .5118 | .5089 | .5065 | .5044 | .5028 |
| −3.0 | .5858 | .5729 | .5618 | .5522 | .5439 | .5366 | .5302 | .5247 | .5199 | .5158 | .5123 | .5092 | .5067 | .5046 | .5029 |
| −3.1 | .5885 | .5753 | .5638 | .5539 | .5453 | .5378 | .5312 | .5255 | .5206 | .5163 | .5127 | .5095 | .5069 | .5047 | .5030 |
| −3.2 | .5911 | .5775 | .5657 | .5555 | .5466 | .5389 | .5322 | .5263 | .5212 | .5168 | .5130 | .5098 | .5071 | .5049 | .5031 |
| −3.3 | .5936 | .5796 | .5675 | .5571 | .5479 | .5400 | .5331 | .5270 | .5218 | .5173 | .5134 | .5101 | .5073 | .5050 | .5032 |
| −3.4 | .5960 | .5817 | .5693 | .5585 | .5492 | .5410 | .5339 | .5278 | .5224 | .5178 | .5138 | .5104 | .5075 | .5052 | .5033 |
| −3.5 | .5983 | .5837 | .5710 | .5600 | .5504 | .5421 | .5348 | .5285 | .5230 | .5182 | .5141 | .5106 | .5077 | .5053 | .5033 |
| −3.6 | .6006 | .5856 | .5726 | .5614 | .5516 | .5430 | .5356 | .5291 | .5235 | .5186 | .5144 | .5109 | .5079 | .5054 | .5034 |
| −3.7 | .6027 | .5874 | .5742 | .5627 | .5527 | .5440 | .5364 | .5298 | .5240 | .5190 | .5148 | .5111 | .5081 | .5055 | .5035 |
| −3.8 | .6048 | .5892 | .5757 | .5640 | .5538 | .5449 | .5371 | .5304 | .5245 | .5194 | .5151 | .5114 | .5082 | .5056 | .5036 |
| −3.9 | .6067 | .5909 | .5771 | .5652 | .5548 | .5458 | .5379 | .5310 | .5250 | .5198 | .5154 | .5116 | .5084 | .5058 | .5036 |
| −4.0 | .6086 | .5925 | .5785 | .5664 | .5558 | .5466 | .5386 | .5316 | .5255 | .5202 | .5157 | .5118 | .5085 | .5059 | .5037 |
| −4.1 | .6105 | .5941 | .5799 | .5675 | .5568 | .5474 | .5392 | .5321 | .5259 | .5206 | .5159 | .5120 | .5087 | .5060 | .5038 |
| −4.2 | .6123 | .5956 | .5812 | .5687 | .5577 | .5482 | .5399 | .5327 | .5264 | .5209 | .5162 | .5122 | .5088 | .5061 | .5038 |
| −4.3 | .6140 | .5971 | .5825 | .5697 | .5586 | .5490 | .5405 | .5332 | .5268 | .5212 | .5165 | .5124 | .5090 | .5062 | .5039 |
| −4.4 | .6156 | .5985 | .5837 | .5708 | .5595 | .5497 | .5411 | .5337 | .5272 | .5216 | .5167 | .5126 | .5091 | .5063 | .5040 |
| −4.5 | .6172 | .5999 | .5849 | .5718 | .5604 | .5504 | .5417 | .5342 | .5276 | .5219 | .5170 | .5128 | .5093 | .5064 | .5040 |
| −4.6 | .6188 | .6012 | .5860 | .5728 | .5612 | .5511 | .5423 | .5346 | .5280 | .5222 | .5172 | .5130 | .5094 | .5064 | .5041 |
| −4.7 | .6203 | .6025 | .5871 | .5737 | .5620 | .5518 | .5429 | .5351 | .5283 | .5225 | .5174 | .5131 | .5095 | .5065 | .5041 |
| −4.8 | .6217 | .6038 | .5882 | .5746 | .5628 | .5524 | .5434 | .5355 | .5287 | .5228 | .5177 | .5133 | .5096 | .5066 | .5042 |
| −4.9 | .6231 | .6050 | .5892 | .5755 | .5635 | .5531 | .5439 | .5360 | .5291 | .5231 | .5179 | .5135 | .5098 | .5067 | .5043 |
| −5.0 | .6245 | .6061 | .5902 | .5763 | .5642 | .5537 | .5445 | .5364 | .5294 | .5233 | .5181 | .5136 | .5099 | .5068 | .5043 |

| | 180 | 170 | 160 | 150 | 140 | 130 | 120 | 110 | 100 | 90 | 80 | 70 | 60 | 50 | 40 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | .3333 | .3333 | .3333 | .3333 | .3333 | .3333 | .3333 | .3333 | .3333 | .3333 | .3333 | .3333 | .3333 | .3333 | .3333 |
| −0.1 | .3247 | .3256 | .3264 | .3272 | .3280 | .3287 | .3294 | .3300 | .3306 | .3311 | .3316 | .3320 | .3323 | .3326 | .3329 |
| −0.2 | .3193 | .3209 | .3223 | .3237 | .3249 | .3261 | .3272 | .3282 | .3291 | .3299 | .3306 | .3313 | .3318 | .3323 | .3327 |
| −0.3 | .3166 | .3186 | .3204 | .3221 | .3236 | .3250 | .3263 | .3275 | .3285 | .3294 | .3303 | .3310 | .3316 | .3322 | .3326 |
| −0.4 | .3160 | .3181 | .3201 | .3218 | .3235 | .3249 | .3262 | .3274 | .3285 | .3295 | .3303 | .3310 | .3316 | .3322 | .3326 |
| −0.5 | .3169 | .3190 | .3209 | .3226 | .3242 | .3255 | .3268 | .3279 | .3289 | .3298 | .3306 | .3312 | .3318 | .3323 | .3327 |
| −0.6 | .3190 | .3209 | .3226 | .3241 | .3254 | .3267 | .3277 | .3287 | .3296 | .3303 | .3310 | .3315 | .3320 | .3324 | .3328 |
| −0.7 | .3219 | .3234 | .3248 | .3260 | .3271 | .3281 | .3290 | .3297 | .3304 | .3310 | .3315 | .3319 | .3323 | .3326 | .3329 |
| −0.8 | .3254 | .3265 | .3274 | .3283 | .3291 | .3297 | .3303 | .3309 | .3313 | .3317 | .3321 | .3324 | .3326 | .3329 | .3330 |
| −0.9 | .3292 | .3298 | .3303 | .3308 | .3312 | .3315 | .3318 | .3321 | .3323 | .3325 | .3327 | .3329 | .3330 | .3331 | .3332 |
| −1.0 | .3333 | .3333 | .3333 | .3333 | .3333 | .3333 | .3333 | .3333 | .3333 | .3333 | .3333 | .3333 | .3333 | .3333 | .3333 |
| −1.1 | .3375 | .3369 | .3364 | .3360 | .3355 | .3352 | .3349 | .3346 | .3344 | .3342 | .3340 | .3338 | .3337 | .3336 | .3335 |
| −1.2 | .3418 | .3406 | .3395 | .3386 | .3378 | .3370 | .3364 | .3359 | .3354 | .3350 | .3346 | .3343 | .3340 | .3338 | .3336 |
| −1.3 | .3460 | .3442 | .3426 | .3412 | .3399 | .3389 | .3379 | .3371 | .3364 | .3358 | .3352 | .3348 | .3344 | .3340 | .3338 |
| −1.4 | .3501 | .3477 | .3456 | .3437 | .3421 | .3407 | .3394 | .3383 | .3374 | .3365 | .3358 | .3352 | .3347 | .3343 | .3339 |
| −1.5 | .3542 | .3511 | .3485 | .3462 | .3442 | .3424 | .3408 | .3395 | .3383 | .3373 | .3364 | .3357 | .3350 | .3345 | .3341 |
| −1.6 | .3581 | .3545 | .3513 | .3486 | .3462 | .3441 | .3422 | .3406 | .3392 | .3380 | .3370 | .3361 | .3353 | .3347 | .3342 |
| −1.7 | .3619 | .3577 | .3541 | .3509 | .3481 | .3457 | .3436 | .3417 | .3401 | .3387 | .3375 | .3365 | .3356 | .3349 | .3343 |
| −1.8 | .3656 | .3608 | .3567 | .3531 | .3500 | .3473 | .3449 | .3428 | .3410 | .3394 | .3380 | .3369 | .3359 | .3351 | .3345 |
| −1.9 | .3691 | .3638 | .3593 | .3553 | .3518 | .3488 | .3461 | .3438 | .3418 | .3401 | .3386 | .3373 | .3362 | .3353 | .3346 |
| −2.0 | .3725 | .3667 | .3617 | .3574 | .3535 | .3502 | .3473 | .3448 | .3426 | .3407 | .3390 | .3376 | .3365 | .3355 | .3347 |
| −2.1 | .3758 | .3695 | .3641 | .3593 | .3552 | .3516 | .3485 | .3457 | .3434 | .3413 | .3395 | .3380 | .3367 | .3357 | .3348 |
| −2.2 | .3789 | .3722 | .3663 | .3612 | .3568 | .3530 | .3496 | .3466 | .3441 | .3419 | .3400 | .3383 | .3370 | .3358 | .3349 |
| −2.3 | .3819 | .3747 | .3685 | .3631 | .3583 | .3542 | .3507 | .3475 | .3448 | .3424 | .3404 | .3387 | .3372 | .3360 | .3350 |
| −2.4 | .3848 | .3772 | .3706 | .3648 | .3598 | .3555 | .3517 | .3484 | .3455 | .3430 | .3408 | .3390 | .3374 | .3361 | .3351 |
| −2.5 | .3875 | .3795 | .3726 | .3665 | .3613 | .3567 | .3527 | .3492 | .3461 | .3435 | .3412 | .3393 | .3376 | .3363 | .3352 |
| −2.6 | .3902 | .3818 | .3745 | .3681 | .3626 | .3578 | .3536 | .3499 | .3467 | .3440 | .3416 | .3396 | .3378 | .3364 | .3353 |
| −2.7 | .3927 | .3839 | .3763 | .3697 | .3639 | .3589 | .3545 | .3507 | .3473 | .3444 | .3420 | .3398 | .3380 | .3366 | .3354 |
| −2.8 | .3952 | .3860 | .3781 | .3712 | .3652 | .3599 | .3554 | .3514 | .3479 | .3449 | .3423 | .3401 | .3382 | .3367 | .3355 |
| −2.9 | .3975 | .3880 | .3798 | .3726 | .3664 | .3610 | .3562 | .3521 | .3485 | .3453 | .3426 | .3404 | .3384 | .3368 | .3355 |
| −3.0 | .3997 | .3899 | .3814 | .3740 | .3675 | .3619 | .3570 | .3527 | .3490 | .3458 | .3430 | .3406 | .3386 | .3370 | .3356 |
| −3.1 | .4019 | .3918 | .3830 | .3753 | .3687 | .3629 | .3578 | .3534 | .3495 | .3462 | .3433 | .3408 | .3388 | .3371 | .3357 |
| −3.2 | .4040 | .3935 | .3845 | .3766 | .3697 | .3638 | .3585 | .3540 | .3500 | .3466 | .3436 | .3411 | .3389 | .3372 | .3358 |
| −3.3 | .4060 | .3952 | .3859 | .3778 | .3708 | .3646 | .3592 | .3546 | .3505 | .3469 | .3439 | .3413 | .3391 | .3373 | .3358 |
| −3.4 | .4079 | .3969 | .3873 | .3790 | .3718 | .3654 | .3599 | .3551 | .3509 | .3473 | .3442 | .3415 | .3393 | .3374 | .3359 |
| −3.5 | .4097 | .3984 | .3887 | .3801 | .3727 | .3663 | .3606 | .3557 | .3514 | .3476 | .3444 | .3417 | .3394 | .3375 | .3360 |
| −3.6 | .4115 | .4000 | .3899 | .3812 | .3737 | .3670 | .3612 | .3562 | .3518 | .3480 | .3447 | .3419 | .3395 | .3376 | .3360 |
| −3.7 | .4132 | .4014 | .3912 | .3823 | .3745 | .3678 | .3619 | .3567 | .3522 | .3483 | .3450 | .3421 | .3397 | .3377 | .3361 |
| −3.8 | .4148 | .4028 | .3924 | .3833 | .3754 | .3685 | .3625 | .3572 | .3526 | .3486 | .3452 | .3423 | .3398 | .3378 | .3362 |
| −3.9 | .4164 | .4042 | .3936 | .3843 | .3762 | .3692 | .3630 | .3577 | .3530 | .3489 | .3454 | .3425 | .3399 | .3379 | .3362 |
| −4.0 | .4180 | .4055 | .3947 | .3853 | .3770 | .3699 | .3636 | .3581 | .3534 | .3492 | .3457 | .3426 | .3401 | .3380 | .3363 |
| −4.1 | .4195 | .4068 | .3958 | .3862 | .3778 | .3705 | .3641 | .3586 | .3537 | .3495 | .3459 | .3428 | .3402 | .3380 | .3363 |
| −4.2 | .4209 | .4080 | .3968 | .3871 | .3786 | .3711 | .3647 | .3590 | .3541 | .3498 | .3461 | .3430 | .3403 | .3381 | .3364 |
| −4.3 | .4223 | .4092 | .3978 | .3879 | .3793 | .3718 | .3652 | .3594 | .3544 | .3501 | .3463 | .3431 | .3404 | .3382 | .3364 |
| −4.4 | .4236 | .4103 | .3988 | .3888 | .3800 | .3723 | .3657 | .3598 | .3547 | .3503 | .3465 | .3433 | .3405 | .3383 | .3365 |
| −4.5 | .4249 | .4114 | .3997 | .3896 | .3807 | .3729 | .3661 | .3602 | .3550 | .3506 | .3467 | .3434 | .3406 | .3384 | .3365 |
| −4.6 | .4261 | .4125 | .4007 | .3903 | .3813 | .3735 | .3666 | .3606 | .3553 | .3508 | .3469 | .3436 | .3407 | .3384 | .3366 |
| −4.7 | .4274 | .4135 | .4016 | .3911 | .3820 | .3740 | .3670 | .3609 | .3556 | .3510 | .3471 | .3437 | .3408 | .3385 | .3366 |
| −4.8 | .4285 | .4146 | .4024 | .3918 | .3826 | .3745 | .3675 | .3613 | .3559 | .3513 | .3473 | .3438 | .3409 | .3386 | .3366 |
| −4.9 | .4297 | .4155 | .4032 | .3925 | .3832 | .3750 | .3679 | .3616 | .3562 | .3515 | .3474 | .3440 | .3410 | .3386 | .3367 |
| −5.0 | .4308 | .4165 | .4041 | .3932 | .3838 | .3755 | .3683 | .3620 | .3565 | .3517 | .3476 | .3441 | .3411 | .3387 | .3367 |

three $A'$ points, one of the three angles, $\phi_{12}$, $\phi_{23}$, or $\phi_{34}$, must be bisected by $A_oB_o$. In Fig. 2, angle $\phi_{34}$ has been positioned in this manner. Length of $A_oB_o$ must be such that angle $A_3B_oA_4$ is equal to $\psi_{34}$. This can be accomplished graphically, or $A_oB_o$ can be computed from

$$(A_o\,B_o) = (A_o\,A)\left[\cos(\phi_{34}/2) + \frac{\sin(\phi_{34}/2)}{\tan(\psi_{34}/2)}\right] \qquad (1)$$

Once point $B_o$ is determined, the solution is the same as that for the three-position problem. By the special choices that have been specified, points $A_3'$ and $A_4'$ will be coincident. Therefore, only three distinct $A'$ points exist. Thus reduction of four $A'$ points to three permits a circle to be drawn through all $A'$ points. If an angle other than $\phi_{34}$ is bisected by $A_oB_o$, two other corresponding $A'$ points will coincide, and the angles involved in Equation 1 will be changed.

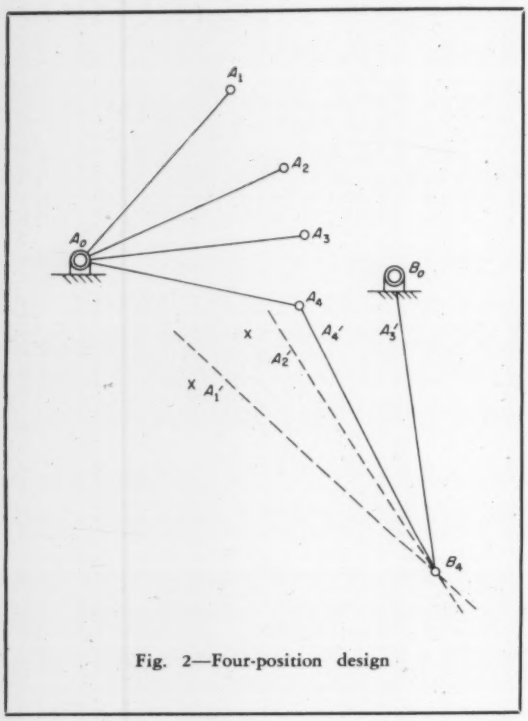



Fig. 2—Four-position design

EXAMPLE 1: Generate the function $y = x^2$ from $x = 0$ to $x = 2.0$, with an input range of 60 deg and an output range of 80 deg.

The points are proportionately spaced in the input range with corresponding values of the output as follows:

| Position | $x$ | $y$ | Input Angles | Output Angles |
|---|---|---|---|---|
| 1 | 0.0 | 0.0 | | |
| | | | $\phi_{12} = 24$ deg | $\psi_{12} = 12.8$ deg |
| 2 | 0.8 | 0.64 | | |
| | | | $\phi_{23} = 18$ deg | $\psi_{23} = 26.4$ deg |
| 3 | 1.4 | 1.96 | | |
| | | | $\phi_{34} = 18$ deg | $\psi_{34} = 40.8$ deg |
| 4 | 2.0 | 4.00 | | |

To set the drawing size, let $A_oA = 2.5$ in. Let the line $A_oB_o$ divide the angle $\phi_{34}$. The value of $A_oB_o$ from Equation 1 is

$$(A_o\,B_o) = 2.5\left[\cos(18/2) + \frac{\sin(18/2)}{\tan(40.8/2)}\right] = 3.52 \text{ in.}$$

The construction for this example is shown in Fig. 2, and lengths of the links are: $A_oA = 2.50$ in., $AB = 3.42$ in., $BB_o = 3.42$ in., and $A_oB_o = 3.52$ in.

**Five Positions:** If five positions are to be satisfied, two pairs of $A'$ points must coincide, and there are many design-position arrangements that are satisfactory. The arrangement of four design positions for the input crank must be such that two of the $\phi$ angles are bisected by $A_oB_o$.

Fig. 3 shows three possible arrangements for these design positions: (*a*) $A_1$ and $A_5$ and $A_2$ and $A_4$ coincide; (*b*) the pairs are $A_1A_5$, and $A_3A_4$; and (*c*) $A_2A_5$ and $A_3A_4$. Angles formed by the corresponding symmetrical $A_oA$ lines vary according to

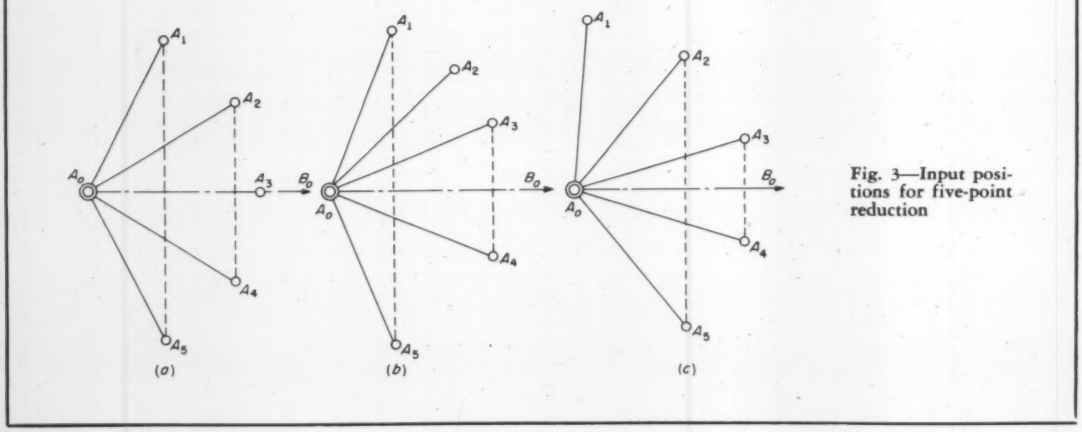



Fig. 3—Input positions for five-point reduction

the location of the design positions. Let the ratio of the larger to the smaller of these angles be $R$. Then in Fig. 3*a*, $R = \phi_{15}/\phi_{24}$; in Fig. 3*b*, $R = \phi_{15}/\phi_{34}$, and in Fig. 3*c*, $R = \phi_{25}/\phi_{34}$.

There exist ratios of a similar nature for the output angles. For Fig. 3*a*, $K = \psi_{24}/\psi_{15} = (y_4 - y_2)/(y_5 - y_1)$, and for Fig. 3*b*, $K = \psi_{34}/\psi_{15} = (y_4 - y_3)/(y_5 - y_1)$. In the solution of problems, the value for $R$ is chosen and $K$ is computed for the desired value of the output function.

Next, ratio $(A_oB_o)/(A_oA)$ is determined such that $K$ satisfies the ratio of the two output angles. This latter step often takes more time than the remaining parts of the design. To simplify the design, Tables 1 and 2 give values of $K$ for ranges of $(A_oB_o)/(A_oA)$ for values of $R = 2$ and $R = 3$. A negative value of $(A_oB_o)/(A_oA)$ implies that $B_o$ lies to the left of $A_o$ instead of to the right.

DESIGN PROCEDURE: The following step-by-step procedure reduces five-position problems to more workable form.

1. Choose the design positions such that $R = 2$ or $R = 3$.
2. Compute the value of output variable $y$ at each design position.
3. Compute the value of $K$.
4. Choose a value for symmetrical range of the input crank.
5. From the tables find the value of $(A_oB_o)/(A_oA)$ that most closely approximates the computed value of $K$. Using interpolation will give extra accuracy for the value of $(A_oB_o)/(A_oA)$.
6. Complete the linkage design using the method described in the three-position problem.

EXAMPLE 2: An arbitrary function shown in Fig. 4*a* is given, and total input range to be used is 100 deg. Let $\phi_{15}$ and $\phi_{24}$ be bisected by $A_oB_o$. If the design positions are to be equally spaced throughout the input range, $R = 2$. The value of $K$ is

$$K = \frac{y_4 - y_2}{y_5 - y_1} = \frac{6 - 1}{7 - 0} = 0.7143$$

Using Table 1 for $R = 2$, under the 100-deg input range column, $(A_oB_o)/(A_oA) = 2.1$ for $K = 0.7031$, and $(A_oB_o)/(A_oA) = 2.0$ for $K = 0.7176$. Interpolating for $K = 0.7143$, $(A_oB_o)/(A_oA) = 2.0225$. For practical design, let $(A_oB_o)/(A_oA) = 2.02$. To determine the drawing scale $A_oA$ is chosen as 2 in. Therefore, $A_oB_o$ is 4.04 in. Once $A_oB_o$ and the five positions of $A_oA$ are drawn, output range $A_1B_oA_5$ is measured. This angle is 58 deg and the input, output, and corresponding angles are

| Position | Input | Output | Input Angles | Output Angles |
|---|---|---|---|---|
| 1 | 0 | 0 | | |
| | | | $\phi_{12} = 25$ deg | $\psi_{12} = 8.3$ deg |
| 2 | 1 | 1 | | |
| | | | $\phi_{23} = 25$ deg | $\psi_{23} = 8.3$ deg |
| 3 | 2 | 2 | | |
| | | | $\phi_{34} = 25$ deg | $\psi_{34} = 33.2$ deg |
| 4 | 3 | 6 | | |
| | | | $\phi_{45} = 25$ deg | $\psi_{45} = 8.3$ deg |
| 5 | 4 | 7 | | |

Completing the design, Fig. 4*b*, yields $A_oA = 2$ in., $AB = 0.81$ in., $BB_o = 2.84$ in., and $A_oB_o = 4.04$ in.

Examining the linkage at the midposition of the input link reveals that the links take a position such that $A_o$, $A$, $B$, and $B_o$ are almost in a straight line. This condition limits the transmitted force. Thus, even though the design satisfied the problem, practical considerations eliminate this design and the linkage should be redesigned for $R = 3$.

In the design of some linkages the five-position design cannot be utilized, but the four-position design can be applied to all problems of the type discussed.

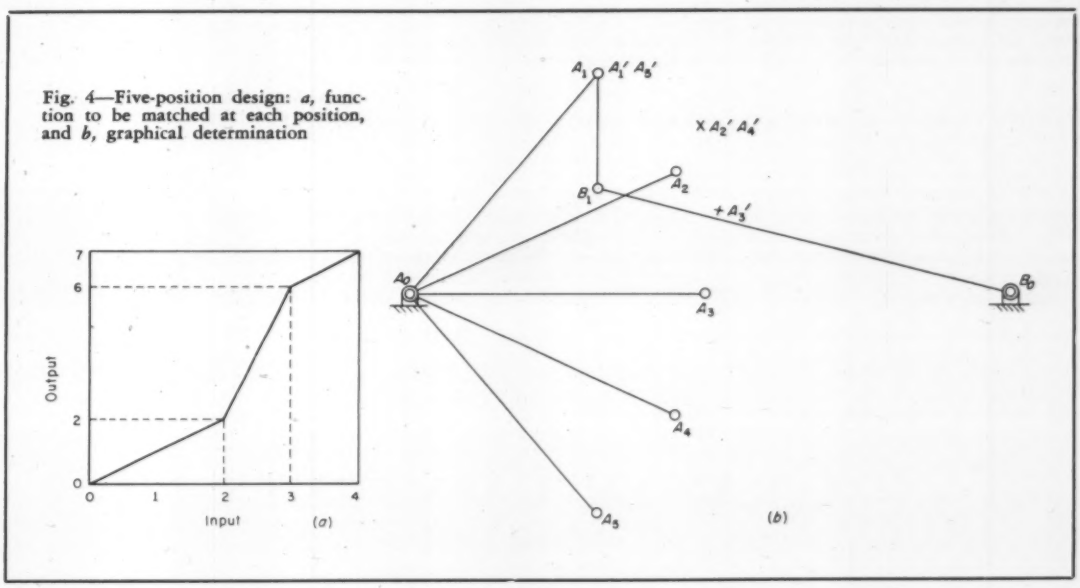



Fig. 4—Five-position design: *a*, function to be matched at each position, and *b*, graphical determination

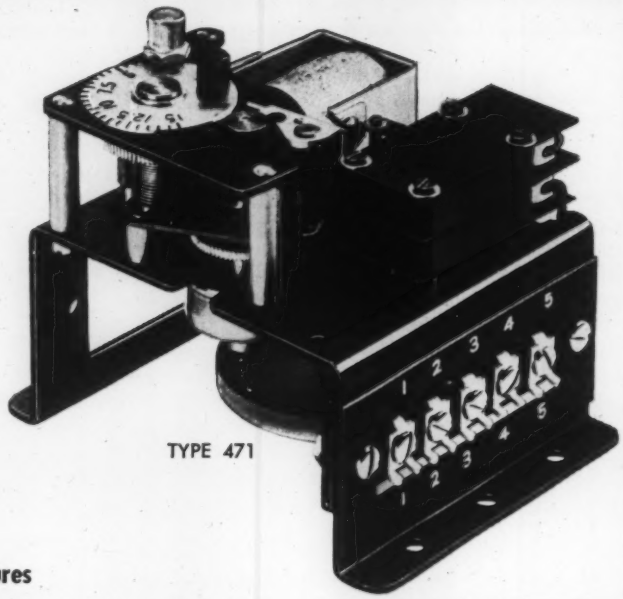
# New adjustable time delay relay provides wide selection of time ranges

The new Cramer Type 471 Time Delay Relay provides an accurate, adjustable time delay between the operation of a control circuit and the subsequent closing or opening of one or two load circuits. Through selection of external wiring connections, the unit offers broad application flexibility and excellent accuracy at modest cost. Some typical uses include control of machine tools, batch processes, heat treating, automatic mixers, electronic devices, and signalling equipment of many kinds.

## Operation

Type 471 is powered by a Cramer synchronous motor which drives precision-cut timing cams through a clutch, from a starting point set by a dial knob. The cams rotate at constant speed to a zero point, where the load switch is transferred. An instant later, a second cam opens the motor circuit. The clutch stays engaged, and the unit does not reset until the operator either opens the clutch circuit for the direct-clutch model, or closes the clutch circuit for the reverse-clutch model.

The direct-clutch unit resets automatically on power interruption, and repeats its complete cycle when power is restored. The reverse-clutch unit simply suspends operation and, when power returns, proceeds to complete the same time interval. Resetting is accomplished by a coil spring which drives the cam carriage back to a movable stop which is positioned by the dial knob. The stop location determines how quickly the cams will reach the switch actuation points, and so determines the timed interval.



TYPE 471

## Features

**TIME RANGES** — 15 seconds to 24 hours.

**ADJUSTMENT RANGE** — 90% of full scale.

**ACCURACY** — within 2% of full scale.

**RESET TIME** — approx. ⅓ second or less.

**LOAD SWITCHES** — snap-acting SPDT, 10A 125V or 5A 250V AC, non-inductive.

**MOTOR & CLUTCH** — 115/220V, 25, 50 and 60 cycles. Reverse clutch optional.

**GEARS** — case-hardened steel, for life in excess of a million operations.

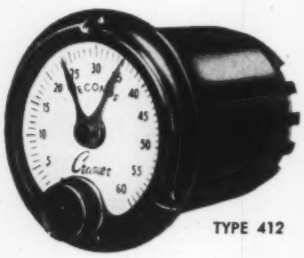
For details, write for your free copy of Bulletin PB-471.

**TIME RANGES AND MINIMUM SETTINGS**

| TIME RANGE | DIAL DIVISIONS | MINIMUM SETTING |
|---|---|---|
| 15 sec. | ½ sec. | 1.5 sec. |
| 30 sec. | 1 sec. | 3 sec. |
| 60 sec. | 2 sec. | 6 sec. |
| 5 min. | 10 sec. | 30 sec. |
| 15 min. | 30 sec. | 1.5 min. |
| 30 min. | 1 min. | 3 min. |
| 60 min. | 2 min. | 6 min. |
| 2 hrs. | 5 min. | 12 min. |
| 5 hrs. | 15 min. | 36 min. |
| 12 hrs. | 30 min. | 1¼ hrs. |
| 24 hrs. | 1 hr. | 2½ hrs. |

## FOR EXTREME ACCURACY PLUS WIDE SELECTION OF RANGES

Type 412 performs essentially the same functions as Type 471, except that it is designed for panel mounting, extreme accuracy, heavier loads, and 100% adjustability over the entire time range of each unit. Eleven full-scale time ranges are available, from 6 seconds to 24 hours. Overall accuracy is within plus or minus ½ of 1% of full scale, exclusive of setting errors. Repeat accuracy is within plus or minus ¼ of 1% of full scale on 30 second and longer ranges, and ½ of 1% of full scale on faster timers. The fully enclosed dial carries a red pointer to indicate the setting, a black pointer to indicate timing progress. The open blade SPDT load switch is rated 15A 125V, 10A 250V AC, and can handle inrush currents up to 40 amperes. A second load, operating within 1% of full-scale time following the first load, can be controlled from the motor switch itself. Internal SPST seal-in contacts permit operation from a 1 10-sec. control pulse if desired. Direct or reverse clutch operation is as described for Type 471.




TYPE 412

# CRAMER CONTROLS
## CORPORATION

Box 6, Centerbrook, Connecticut



Circle 482 on Page 19

# DE[redacted]TS

## electrical

### Elements of Reversible Induction Motor Drives

*W. Leonhard, Westinghouse Electric Corp.*

A discussion and comparison of several alternative reactor circuits for reversible motor control on the basis of their "open loop" properties. Principles of the control operations are explained. Numerical data derived are suitable for comparison of the different circuits. Test results indicate that this theory, despite its simplicity, offers an adequate description of major phenomena. A four-reactor control circuit is most desirable for a medium-power application because it combines acceptable electrical symmetry with good operational characteristics. Also, it offers a cost compromise between simpler control schemes with high electrical asymmetry and the fully symmetrical, but more expensive, five or six-reactor control circuits. Development is directed toward the more extensive use of motors with simple eddy current rotors.

*AIEE paper* 58-1176, *prepared for the AIEE Fall General Meeting, Pittsburgh, October,* 1958; 14 *pp.*

### Stability of Automatic Control Systems

*E. A. Freeman, The English Electric Co. Ltd.*

Effects of speed-dependent friction and backlash on control-system stability. The limit to the accuracy with which a motor and load can be connected is inherent in the design of remote-position control systems. As restrictions on the accuracy of control become more critical, the effect of backlash on system performance assumes greater importance. For this reason, its effect on system stability is investigated using a describing-function technique. A method of deriving the describing function is given. A correct choice of system parameters obviates any oscillation of the system.

*AIEE paper* 58-1268, *prepared for the AIEE Fall General Meeting, Pittsburgh, October,* 1958; 26 *pp.*

## materials

### Practical Uses of Porcelain Enamels to 1400 F

*H. R. Spiers, Penco Corp.*

A discussion of the practicality of certain porcelain enamels for applications in the 1400 F temperature range. These materials permit a wide use of cold-rolled steel as the base metal and, in many cases, a reduction in the gage of the steel. Also, they permit firing the ground coat and cover coat in the same time-temperature cycle.

*PEI paper, Twentieth Annual Shop Practice Forum of the Porcelain Enamel Institute, Urbana, Ill., November,* 1958; 6 *pp.*

### Ceramic Adhesives

*Henry G. Lefort*

A discussion of ceramic adhesives which are similar in composition to porcelain enamels and suitable for bonding stainless steel. Data on physical properties and the compositions of these adhesives are included. Properties are evaluated by means of tensile shear specimens and bonded honeycomb panels. Shear tests show excellent cohesive and adhesive properties of ceramic bonds at high temperatures, and thermal expansion compatibility of the metal and bond. Recommendations for the selection and application of ceramic adhesives and elements of joint design are covered. Adhesives are suitable for application to 1000 F at pressures to 2000 psi.

*PEI paper, Twentieth Annual Shop Practice Forum of the Porcelain Enamel Institute, Urbana, Ill., November,* 1958; 15 *pp.*

### Electrical Properties Of Porcelain Enamels

*C. G. Bergeron, University of Illinois*

Data on room temperature and high-temperature electrical properties of various porcelain-enamel coatings. These properties are compared with those of currently used insulation materials. Porcelain enamel insulators offer definite advantages over certain types of organic insulators in high-temperature applications. Although dielectric properties of the enamels change markedly with increasing temperature, other properties remain unaffected. Electrical properties can be improved by varying the compositions.

*PEI paper, Twentieth Annual Shop Practice Forum of the Porcelain Enamel Institute, Urbana, Ill., November,* 1958; 13 *pp.*

### The Development of Cermets

*G. C. Deutsch, A. J. Meyer Jr., and G. M. Ault*

The definition and nature of cermets. Physical and mechanical

properties of cermets are included with special reference to the normally poor impact strength and ductility of these materials. Possible ways are considered in which these two properties might be improved. Approach to property improvement is through the altering of the composition of the metal and ceramic phases and through changing other variables in the microstructure. Industrial applications of cermets include containers for liquid metals, certain special bearings, thermocouple protection tubes, and cold heading and extrusion dies. A report on the feasibility of cermets for turbine blading is included.

*NATO report* 185, *Seventh Meeting of the Structures and Materials Panel*, 1958; 20 *pp.*

# mechanical

## Relief of Thermal Stresses Through Creep

*H. Poritsky and F. A. Fend, General Electric Co.*

Development of equations for analyzing effects of thermal creep on stress distribution. A numerical procedure permits stress and strain components to be computed successfully at the end of various time intervals. It is assumed that the initial creep rate remains constant during each time interval. Resulting equations are applied to the axially symmetric problem of relief of thermal stresses in an infinitely long cylinder which is quickly heated to a radial temperature distribution and maintained at that temperature. Methods developed illustrate a procedure which can be followed for other stress-creep problems.

*ASME paper* 58-A-41, *ASME Annual Meeting, New York, December*, 1958; 9 *pp.*

## Reappraising Spring Forms As Aids to Design

Advantages of the flat spring for many design applications. Most wire springs are single purpose but, with flat springs, it is often possible to achieve two or more functions. Various applications showing the multiple functions of flat springs are analyzed. How belleville washers are used in applications to absorb manufacturing tolerance buildups in component parts are covered. Varying the ratios of height to thickness of the washers makes it possible to obtain a load-deflection curve which is a straight line, a flat-topped curve with a section having a range of deflection with little or no change in load, or characteristic load which increases, reaches a peak, and rapidly declines.

The Main Spring, *Spring No.* 17, *Coil No.* 9, *November*, 1958; 7 *pp.*

## The Better Way To Make a Cam

A series of case histories showing how intricate cam designs are made simply and economically by powder metallurgy. Problems of machining cam profiles and how these problems may be eliminated are covered. Mechanical properties of high-density iron powder parts are included.

Powder Metallurgy Quarterly, *Fall*, 1958; 6 *pp.*

## The Compression of Bonded Rubber Blocks

*A. N. Gent and P. B. Lindley, British Rubber Producers Research Assoc.*

A report on the experimental measurement of the load-deflection relation for rubber blocks for various thicknesses and a variety of cross sections. Elastic behavior is analyzed and applied to various rubber components in structures and machines. An approximate theoretical treatment is presented for small compressions of circular discs and infinitely long, rectangular bars. Measured stiffness for small compressions is shown to be in good agreement with theoretical predictions for a rubber containing no carbon black.

*Prepared for the Institution of Mechanical Engineers (Great Britain)*; 9 *pp.*

# techniques

## Logic Design Techniques of Static Switching Control

*J. W. Stuart and R. A. Manning, Westinghouse Electric Corp.*

Design procedures and techniques used in the development of a static switching control system for transfer machines. Logic functions inherently offer a direct approach to control design. Complexity of design is minimized by breaking the control down into modular circuits on a functional basis. A step-by-step procedure is outlined, and a brief review of static switching symbols and logic characteristics is included.

*AIEE paper* CP58-1284, *prepared for the AIEE Fall General Meeting, Pittsburgh, October*, 1958; 9 *pp.*

## Parameter Methods For Extrapolating Data

*R. M. Goldhoff, General Electric Co.*

A discussion of the controversial and contradictory parameter techniques for correlation of high-temperature stress-rupture data. Parameters are treated with a view toward their application in extrapolating short-time data to predict working stresses in serviceable heat-resistant alloys. Three methods are compared on a statistical basis for their ability to reproduce isothermal data on which they are based and, in particular, the longest time data currently available and usable for this purpose. Prediction of long-time working stresses using parameter techniques will generally give better results than can be obtained from long extrapolations on double logarithmic flats. For reliable extrapolations all methods require data from tests to 1000 hr and covering adequate ranges of stress and temperature.

*ASME paper* 58-A-121, *ASME Annual Meeting, New York, December*, 1958; 15 *pp.*

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*PEI*—Porcelain Enamel Institute Inc., Associations Bldg., Rm. 315, 1145 19th St., N. W., Washington 6, D. C.

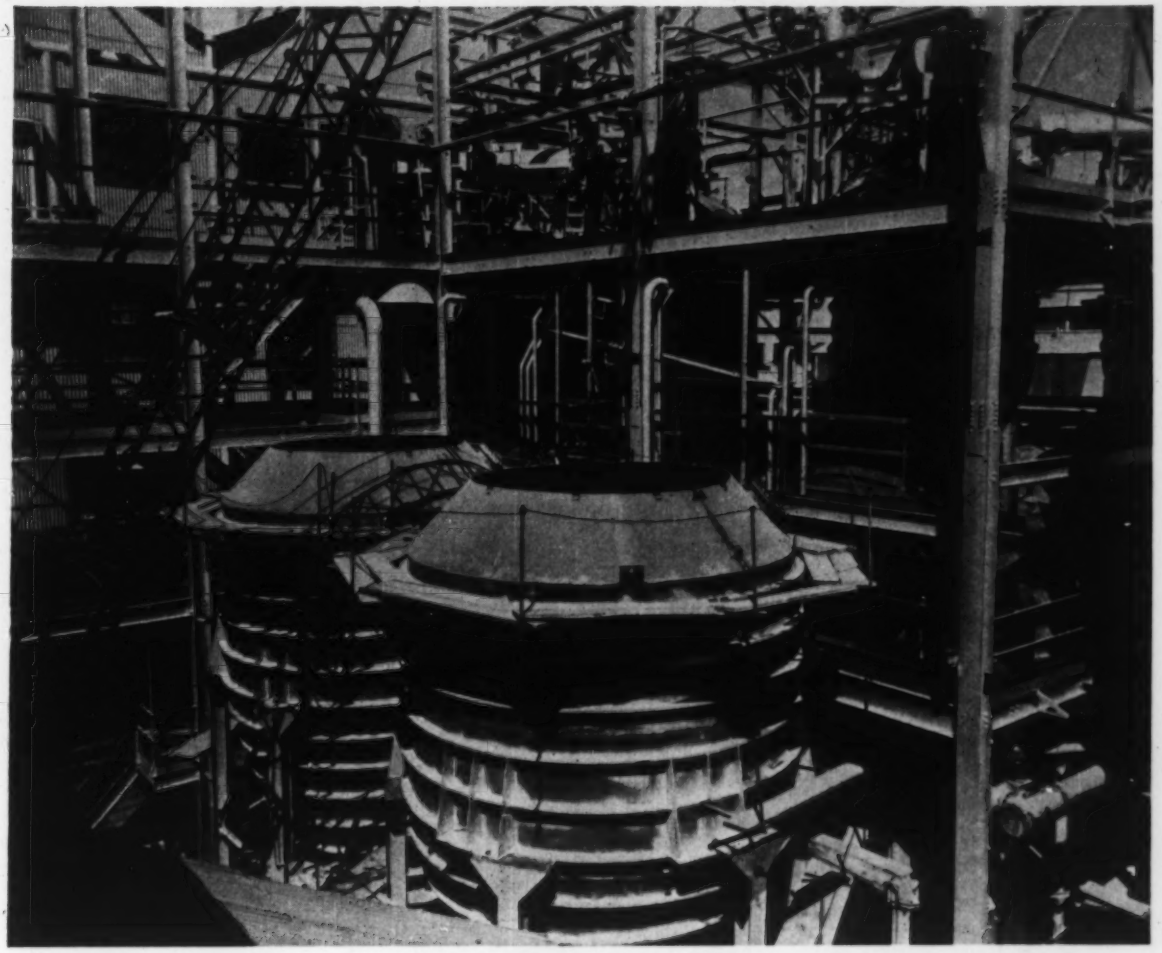
*NATO*—National Aeronautics and Space Agency, 1512 H St., N. W., Washington 25, D. C.

*ASME*—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; papers 40 cents to members, 80 cents to nonmembers.

*Powder Metallurgy Quarterly*—Metal Powder Industries Federation, 130 West 42nd St., New York 36, N. Y.

*The Mainspring*—Associated Spring Corp., Bristol, Conn.

The Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, S.W. 1.



The potash crystallizers under construction above are two of seven that were shop- and field-fabricated, then field-assembled by welding. Although these units were not stress-relieved or heat-treated, there was no sign of stress-corrosion cracking after a year.

# No stress-relieving here —no stress-corrosion cracking!

## Field-assembled from NEW AMPCO METAL GRADE 8

Improved Ampco Metal Grade 8 puts an entirely new slant on fabricating copper-base alloy equipment to handle steam and corrosive media at elevated temperatures.

At a major oil refinery, for example, field-welded piping of Ampco Metal Grade 8 has handled hot sulphuric-acid sludge for a year and a half without stress-corrosion cracking.

New, patented Ampco Metal Grade 8 also simplifies field repairs and alterations. You can weld readily with any electric process, without pre-heat or post-heat and without hot-short cracking.

Talk this over with your Ampco field engineer. Or write *Ampco Metal, Inc., Dept. 31-/ Milwaukee 46, Wis. West Coast plant: Burbank, Calif. — Southwest plant: Garland (Dallas County), Texas.*

TS-6

AMPCO®

# Helpful Literature
## for Design Executives

**For copies of any literature listed, circle Item Number on Yellow Card—page 19**

### Limit Switches

Details of three types of Micro Switch heavy-duty limit switches for industrial uses are provided in Catalog 84. It lists units with a variety of contact arrangements, for either direct or alternating-current, and shows several actuator designs. 16 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill. K

*Circle 601 on Page 19*

### Insulations

Management; financial strength; and research, development, engineering, and production capabilities of company are reviewed in special report. Ultra high and low temperature insulations, thermal and acoustical glass fiber, reinforced plastics, and structural core materials are shown and described. 36 pages. H. I. Thompson Fiber Glass Co., 1733 Cordova St., Los Angeles 7, Calif. L

*Circle 602 on Page 19*

### Motor-Pumps

Twenty sizes of K line Motorpumps are outlined in Bulletin 70022. Units are offered in ⅓ through 25-hp sizes for heads to 190 ft and capacities to 775 gpm. Features of Motorpump impellers, seals, casings, and drive motors are highlighted. 8 pages. Ingersoll-Rand Co., 11 Broadway, New York 4, N. Y. C

*Circle 603 on Page 19*

### Pressure Gages

Line of Helicoid precision pressure gages graphically described in Catalog DH-65 is suitable for various industrial processing and chemical applications subjected to violent pressure pulsations or severe mechanical vibrations. Booklet covers types of systems, applications, specs, and accessories. 36 pages. American Chain & Cable Co., Helicoid Gage Div., 929 Connecticut Ave., Bridgeport 2, Conn. B

*Circle 604 on Page 19*

### Hydraulic Piston Pumps

Two specification sheets respectively describe the PF-3021 and the PF-6015 hydraulic piston pumps. Representative performance curves are shown. Models are respectively rated at 3000 and 6000 psi and deliver 43.0 and 50.7 peak intermittent hp. 2 pages each. Dynex Inc., 777 Dynex Dr., Pewaukee, Wis. K

*Circle 605 on Page 19*

### Variable Speed Pulleys

Comprehensive information relative to the 400 series variable speed pulleys is provided in Catalog 70. Variable-speed pulley is offered in ratings to 15 hp and speed ranges up to 4:1. Combination pulleys in ratings to 25 hp and speed ranges to 10:1 are also reviewed. 26 pages. Lewellen Mfg. Co., Columbus, Ind. J

*Circle 606 on Page 19*

### Quick-Release Fasteners

Design improvements made in Pip Pins, self-locking quick-release fasteners, are pointed up in Bulletin ADI 6500 along with tabulated dimensions. Easier-to-operate T and L handles, and release buttons of these fasteners speed removal or assembly of portable equipment. 2 pages. Aviation Developments Inc., 210 S. Victory Blvd., Burbank, Calif. L

*Circle 607 on Page 19*

### Rubber-Metal Products

Bearings, bushings, couplings, mounts, sleeves, and molded shapes are among the rubber-metal products reviewed in illustrated catalog. Characteristics of mechanically and chemically bonded components are described. Design information, including formulas for determining radial, torsional, axial, and conical loadings, is included. 12 pages. Clevite Harris Products, Inc., Dept. A, Lockwood Rd., Milan, Ohio. G

*Circle 608 on Page 19*

### Turret Drill

How to perform several different machining operations on the bench model Burgmaster turret drill is related in folder CDG 8799. Machine will instantly index from one drill size to another, or from one type of operation to another. Typical uses are shown. 4 pages. Burgmaster Corp., 13226 S. Figueroa St., Gardena, Calif. L

*Circle 609 on Page 19*

### Oils, Greases & Solvents

Information in products folder covers general and special lubricants, greases, diesel lube oils, metalworking oils, hydraulic and heat-transfer oils, rubber process aids, waxes, petrochemicals, solvents, refrigeration oils, and electrical oils. 12 pages. Sun Oil Co., Industrial Products Dept., 1608 Walnut St., Philadelphia 3, Pa. E

*Circle 610 on Page 19*

### Malleable Castings

"Modern Pearlitic Malleable Castings Handbook" is a ready reference to latest data on this material. Chapters cover the introduction to the material, castings, fact and figures for design, and applications. Ten tables, 19 charts, and 14 illustrations are included. 76 pages. Malleable Research and Development Foundation, Granville 1, Ohio. F

*Circle 611 on Page 19*

### Temperature Sensing Units

Advantages of diaphragm temperature sensing devices for controlling temperatures up to 650° F are outlined in bulletin. They are used in many appliance controls. 2 pages. Robertshaw-Fulton Controls Co., Bridgeport Thermostat Div., Milford, Conn. B

*Circle 612 on Page 19*

### Electronic Components

Electronic components and Croname products catalogued in Form 5C5 are intended for original equipment and replacement. Supplementary Bulletin 5K7 describes Waldom solderless terminals. 20 pages. Waldom Electronics Inc., 4625 W. 53rd St., Chicago 32, Ill. I

*Circle 613 on Page 19*

### Ferromagnetic Materials

Data on new types of Ferrotron ferromagnetic materials which operate in up to 350° C are provided in Bulletin BR-10. Physical and electromagnetic property values are covered. 4 pages. Polymer Corp. of Pennsylvania, Reading, Pa. C

*Circle 614 on Page 19*

### Metal-Clad Switchgears

Line of 4160-v metal-clad switchgear featured in Bulletin 2804-1A includes indoor, and standard and walk-in outdoor type equipment with ratings through 3000 amp continuous current and 350 mva interrupting capacities. 22 pages. I-T-E Circuit Breaker Co., 1900 Hamilton St., Philadelphia 30, Pa. C

*Circle 615 on Page 19*

### Rotary Vibrator Motors

Enclosed vibrator motors for light and heavy duty operation of vibrating chairs, beds, tables, and pillows are subject of Bulletin GED-3756. Various mounting arrangements are shown and performance data given. 4 pages. General Electric Co., Schenectady 5, N. Y. C

*Circle 616 on Page 19*

### Three-Way Valves

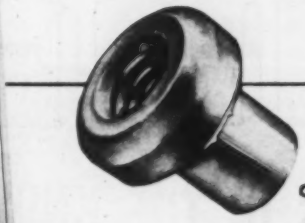
Two available bulletins, 91011 and 91009, respectively, deal with electrically operated three-way valves for air, oil, water, or vacuum service and the E.V.C. series valve and cylinder combination rated 0-200 psi. 12 and 6 pages, respectively. Airmatic Valve, Inc., 7313 Associate Ave., Cleveland 9, Ohio. G

*Circle 617 on Page 19*

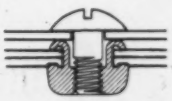
*Applied with standard TRS riveting machines*

# TRS® PERMA-NUTS SAVE TWICE!

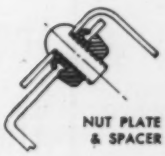
Perma-Nuts
Cost-cutting Internally Threaded Tubular Rivets Automatically Fed and Set by Standard TRS Riveting Machines



*Typical of scores of problems solved best with Perma-Nuts*



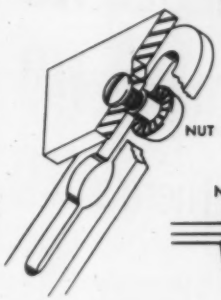
NUT & RIVET & SPACER



NUT PLATE & SPACER

IN TIGHT SPOTS

FLUSH MOUNTED NUT PLATE



NUT & BUSHING

NUT & RIVET

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**1** — *How and where to use them to simplify design and assembly problems*

**2** — *How they are automatically fed and set by standard TRS riveting machines to cut production time & cost*

It will pay to keep versatile PERMA-NUTS in mind when you are specifying attachments and fastenings. Often you can use them to simplify design and reduce costs of an assembly . . . make it better, too.

They provide three to four strong threads to accept a machine screw, and allow direct design conversion from hexagonal nuts. Serrations under the head lock the Perma-Nut securely against turning . . . no need for a washer or key.

Remember, too, that this unique one-piece rivet and nut assures an extra economy . . . a *production* economy. No need for special equipment . . . no slow manual setting when you use Perma-Nuts. They can be automatically fed and set by standard TRS riveting machines.

Get acquainted with this dual cost-cutting device. SEND COUPON for new Perma-Nut Catalog.

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QUINCY 70, MASSACHUSETTS

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Company .....

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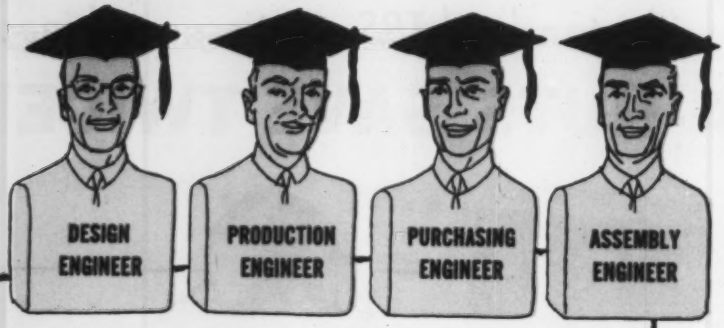


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Circle 485 on Page 19

HELPFUL LITERATURE

## Molybdenum in Steel Castings

"The Role of Molybdenum in Steel Castings for Industrial Equipment" is title of booklet prepared by Prof. J. Wallace of Case Institute of Technology. It covers hardenability, tensile properties, fatigue, hardness, wear and impact resistance, machinability, and weldability. 36 pages. Climax Molybdenum Co., 500 Fifth Ave., New York 36, N. Y. D

Circle 618 on Page 19

## Recycling Timers

Synchronous motor driven recycling timers described in Bulletin 500 are tandem units with two adjustable and continuous time cycles. Maximum time cycles range from 6 sec to 3 hr. Also described Series PC timer is offered in 15 sec to 4 hr time cycles. 4 pages. Industrial Timer Corp., 1407 McCarter Highway, Newark 4, N. J. D

Circle 619 on Page 19

## Tracing Templates

A package of over 14 design tracing templates for designers, engineers, and those developing specific mechanical systems is offered free upon written request. They can be used for breadboard layouts, prototypes, design production, technical sketching, and detail parts drawings. PIC Design Corp., 477 Atlantic Ave., East Rockaway, Long Island, N. Y. D

Circle 620 on Page 19

## Precision Resistors

Wall chart, designated the MIL-Bell Decade Table, tabulates standard resistance values of precision film resistors. It complies with Military Standard 90169 and aids in specification of company's resistors. Texas Instruments, Inc., Box 312, Dallas, Texas. P

Circle 621 on Page 19

## Vinyl Epoxy Plasticizers

A new series of improved epoxy plasticizers with built-in stabilizing properties are subject of Bulletin 101. Complete details on this material and its use are given in technical reprint. Food Machinery & Chemical Corp., Becco Chemical Div., Buffalo 7, N. Y. N

Circle 622 on Page 19

## Air Motors

Over 100 models of I-R air motors with outputs ranging from 0.3 to 24 hp and speeds of 50 to 2580 rpm at rated horsepower are detailed in Bulletin 5072A. Both Multi-Vane and Piston motors are listed, together with complete specifications. 16 pages. Ingersoll-Rand Co., 11 Broadway, New York 4, N. Y. C

Circle 623 on Page 19

## Rolled Alloys

File Folder No. 107 contains technical information on RA330 heat resisting alloy. This material combines strength and resistance to carburization, oxidation, and thermal shock. Fabrication procedures are discussed. 4 pages. Rolled Alloys, Inc., 5309 Concord, Detroit 11, Mich. H

Circle 624 on Page 19

# THERE MUST BE AN EASIER WAY

OLD PURSEWAD HATES TO PART WITH ANYTHING... ESPECIALLY OLD DRAWINGS!!
JUST PUT A LITTLE MORE TAPE ON THESE... AND THEY'LL LAST FOR YEARS!!
I CAN'T DRAW ON THESE THINGS...THEY'RE ALL TAPE NOW!
I'VE HAD MY GLASSES CHANGED 4 TIMES AND I STILL CAN'T READ 'EM
THE ONLY THINGS THAT SHOW UP ON THE BLUEPRINTS ARE TAPEMARKS AND CREASES
IT'S GOOD THE GUYS IN THE SHOP HAVE GOOD MEMORIES
HE SHOULD CALL IN A JUNKMAN...OR ASK A BLUEPRINTER ABOUT AUTOPOSITIVE PAPER INTERMEDIATES

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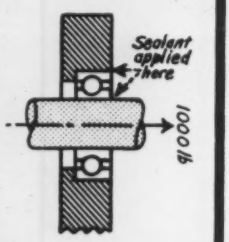
*Edwin F. Oblinger, Chief Engineer, Parker Sweeper Company, says:*

## "WE THREW OUT PRESS FITS FOR BEARINGS..."

"We used interference fits to prevent bearing races from turning in the gear box of our 4HP Turbosweeper. Maintaining close tolerances was a constant headache. If the fit was loose, the race would slip and fret the surfaces; if the fit was tight, the race would deform and bearing life would be shortened. Then we discovered LOCTITE Liquid Sealant would do away with the need for press fits. We opened up the tolerances for both shaft and housing and used a slip fit, filling the clearance with LOCTITE. The bearings are retained with a force equal to the customary interference fit, but we've reduced rejected parts from 8% to less than 1% and reworked parts fell from 20% to 0! Field reports are excellent."

LIQUID SEALANT ... replaced interference fits and opened up tolerances almost 0.002 in. on shaft and housing for this ball bearing assembly. Load of over 1000 lbs. is needed to break bond.




LOCTITE is a penetrating liquid that hardens only after being confined between closely fitted metal parts. In the absence of air, the sealant hardens into a strong, heat and oil-resistant bond. The hardening action may be accelerated by heating.

LOCTITE eliminates the need for interference fits on bearings, sleeves, shafts and studs ... locks nuts to bolts, seals pipe and tubing joints. For literature and free sample, write to:

LOCTITE® SEALANT

AMERICAN SEALANTS COMPANY
111 Woodbine St., Hartford 6, Conn.
Stocked by bearing and industrial distributors.

Circle 487 on Page 19

HELPFUL LITERATURE

### Bellows Flow Meter

Catalog C22-1 descriptively covers the bellows flow meter for flow measurement as well as open and closed tank liquid level measurement. Units are available in pressure ranges from 0-20 to 0-400 in. of water. Booklet shows advanced features and rectangular case instruments with bellows meter body integrally mounted. Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Windrim Aves., Philadelphia 44, Pa. F

Circle 625 on Page 19

### Stainless Tubular Products

Technical data contained in Bulletin TDC-190 on 18-8 Group stainless steel tubular products include analyses, corrosion and oxidation resistance, high and low temperature characteristics, physical and mechanical properties, and fabrication guidance. 8 pages. Babcock & Wilcox Co., Tubular Products Div., Beaver Falls, Pa. G

Circle 626 on Page 19

### DC Motors

Features, dimensions, and technical specs on Moto-Mite permanent-magnet precision direct current motors for missile and aircraft use are presented in Bulletin X-112. They are nominally rated 1/45 and 1/30 hp continuous duty at 10,000 rpm., and have a 26-v dc winding. 2 pages. Globe Industries, Inc., 1784 Stanley Ave., Dayton 4, Ohio. G

Circle 627 on Page 19

### Thermostat Metals

Developed to save engineering time in determining the correct thermostat-metal element size and properties for new applications, Bulletin TRU-8 lists metal types, their thermal deflections, and mechanical and restrained force. Use of table determines size and performance of various elements made of over 40 metals. 4 pages. Metals & Controls Corp., General Plate Div., Attleboro, Mass. B

Circle 628 on Page 19

### Pancake Motor

Engineering information contained in Bulletin 2150 deals with the performance, design, and applications of the new dripproof Pancake Motor which is up to 54 per cent shorter than conventional motors. It is offered in ratings from 1 to 15 hp, and it can be furnished with an integrally mounted brake. 4 pages. Louis Allis Co., 427 E. Stewart St., Milwaukee 1, Wis. K

Circle 629 on Page 19

### Molded Glass Fiber

Molded glass fiber and the techniques used to produce it are subject of illustrated catalog. In addition to describing the physical, mechanical, and electrical properties of plastic impregnated glass fiber materials, it covers the fabricating and finishing operations that can be performed. Custom molding service of company is detailed. 32 pages. Molded Glass Fiber Companies, Ashtabula, Ohio. F

Circle 630 on Page 19

IMMEDIATE DELIVERY!

ON 3/8" AND 1/2" O.D.

*Non-Magnetic*

18-8 TYPE 303 STAINLESS

UNIVERSAL JOINTS

Manufacturers of electronic equipment have come to depend on Curtis for precision-made non-magnetic universal joints of 18-8 Type 303 stainless steel, in the sizes most frequently used in the industry. Other sizes are also readily available; also bronze joints.

Curtis joints benefit by a rigid insistence on uncompromising inspection and quality control at every stage of manufacture, insuring minimum backlash.

Curtis torque and load ratings are entirely dependable, since they are based on continuous testing under actual operating conditions.

Not sold through distributors. It will be to your advantage to write or phone (REpublic 7-0281) for free engineering data and price list.

CURTIS TRADE MARK

UNIVERSAL JOINT CO., INC.
5 Birnie Avenue, Springfield, Mass.

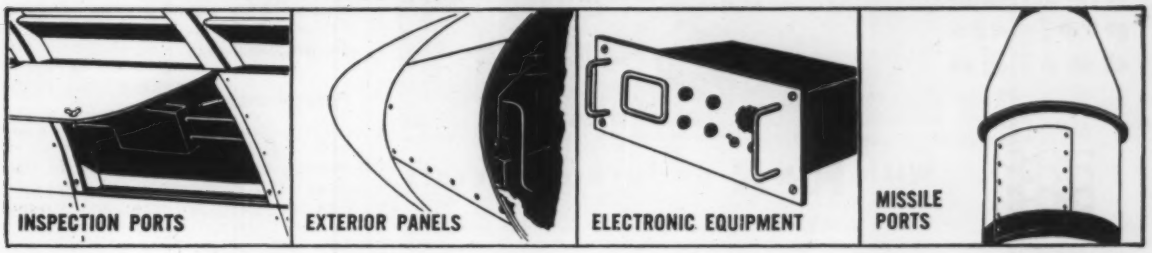
*As near to you as your telephone*

A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

Circle 488 on Page 19

# FLIGHT-PROVED RELIABILITY . . .

## LION *Quarter-turn* FASTENERS FOR SECURING REMOVABLE SECTIONS




Southco's Lion Quarter-turn Fasteners provide quick access and reliable securing of hinged or completely removable panels. Resistance to severe heat, shock and vibration, and a high strength-weight ratio make these unique fasteners ideal for use in private, commercial or military aircraft and missiles . . . for ground production and control or airborne applications.

Lion Fasteners consist of three parts . . . a one-piece, swaged-nose stud; a retainer; a floating receptacle which is riveted or welded in place. Installation requires no special tools . . . is simplified by a permissible float of .070".

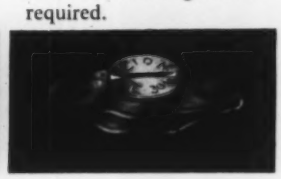
### SWAGED NOSE

Case hardened one-piece stud with swaged nose has no milled sections, inserts, or cross pins . . . requires no wire spring to hold it in locked position. Lion Fasteners offer the highest weight-strength ratio available.

### 2 TYPES AVAILABLE

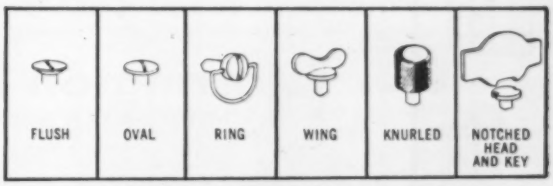
**LION NO. 2 FASTENER**
For use where space is limited and where weight must be kept at a minimum.

**LION NO. 5 FASTENER**
For heavy-duty applications where good tensile and shear strength are required.



### FULL RANGE OF HEADS

Lion No. 2 Fastener available with flush, oval or wing type. No. 5 with flush, oval, ring, wing, knurled or notched head and key.




### OTHER SPECIFICATIONS

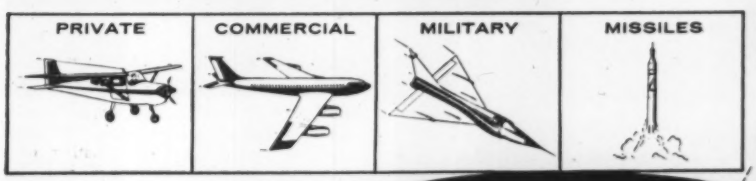
**LION NO. 5 QUARTER-TURN FASTENERS CONFORM TO MIL. SPEC. MIL-F-5591A (ASG) . . . ARE ON THE GOVERNMENT'S QPL . . . ARE CAA APPROVED FOR COMMERCIAL AND PRIVATE AIRCRAFT USE.**

**MATERIAL:** Cadmium-plated case-hardened steel.

## FREE!

### FASTENER HANDBOOK

Send for your free copy of Southco Fastener Handbook No. 8. Gives complete engineering data on Lion Fasteners and many other special fasteners. Write to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.




## LION *Aviation* FASTENERS

one of the SOUTHCO FASTENERS LION

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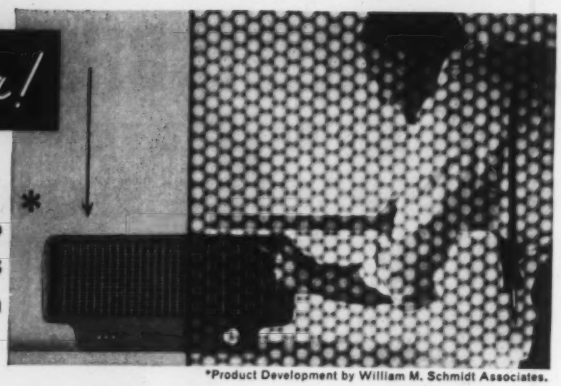


Idea!

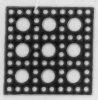
mock-up projects design

*Product Development by William M. Schmidt Associates.

with H&K perforated metals

A few of the thousands of H & K patterns are illustrated in reduced size

Send today to nearest H & K office for General Catalog



Here is an H & K perforated metal grille utilized in a mock-up of a record player. This greatly helps the Industrial Designer project his concepts as H & K perforated metal is now in its proper element for consideration of use and selection of pattern.

By referring to the H & K General Catalog, the designer can select one or more patterns for his project.

H & K perforated metals provide the Industrial Designer, and other men of ideas, a medium of unlimited opportunities for designing better and more attractive products.

THE Harrington & King PERFORATING CO. INC.

Chicago Office and Warehouse
5670 Fillmore Street
Chicago 44, Illinois

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114 Liberty Street, Dept. MD
New York, New York

Circle 490 on Page 19



RUGGED and RELIABLE

New!

TRANSISTORIZED

The A. W. HAYDON COMPANY'S TRANSISTORIZED SUB-MINIATURE ELECTRONIC TIME DELAY RELAYS!

MINIATURE ELECTRONIC TIME DELAY RELAYS 31200 SERIES

SUB-MINIATURE ELECTRONIC TIME DELAY RELAYS 31300 SERIES

SAVE SPACE AND WEIGHT!

| | Miniature Series | Sub-Miniature Series |
|---|---|---|
| Cross Section | 17/16" x 131/32" | 31/32" x 13/16" |
| Length | 2¼" long | 2" long |
| Weight | 6 ounces | 3 ounces |
| WRITE FOR: | Bulletin AWH TD-503 | Bulletin AWH TD-504 |

TEST-PROVED PERFORMANCE!
High Temperature: 125°C (250°F)
Vibration: 2000 CPS at 15 g
Contact arrangements up to 4 pole double throw
Unique transistorized R.C. time constant network
Time Delays from 50 MS to 120 seconds. Longer Delays available
Hermetically sealed housings

MEET REQUIREMENTS OF MIL-E-5272A

The A.W. HAYDON Company

249 NORTH ELM STREET, WATERBURY 20, CONNECTICUT

Design and Manufacture of Electro-Mechanical Timing Devices

Circle 491 on Page 19


HELPFUL LITERATURE

## Coated Steel Tubing

How designers can use coated steel tubing for parts and products is shown in Bulletin PO-5558. Properties of Zincgrip, Aluminized steel Type 1, and Type 2 are listed, and sizes and gages are recommended for typical products. 6 pages. Armco Steel Corp., 5558 Curtis St., Middletown, Ohio. G

Circle 631 on Page 19

## Potentiometers

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Circle 632 on Page 19

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Circle 633 on Page 19

## Teflon & Rubber Tapes

Briefly covered in illustrated folder are Temp-R-Tape pressure-sensitive and self-adhesive Teflon, glass fiber, and silicone rubber tapes for −100 to 500° F temperature electrical and mechanical applications. Also detailed are silicone rubber, sponge, and coated sheets for gasket, pad, diaphragm, and cushion uses. 4 pages. Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn. B

Circle 634 on Page 19

## Control Motor

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Circle 635 on Page 19

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Circle 638 on Page 19

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Circle 639 on Page 19

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Basic engineering data and specifications on ¼ to 3-in. hexagon nuts, ¼ to 5/8-in. 12-pointer nuts, and ¼ to 1½-in. Conelok, Huglok, and Marsden locknuts are contained in condensed catalog. 8 pages. National Machine Products Co., 44225 Utica Rd., Utica, Mich. H

Circle 644 on Page 19


**CONTROL** the finish ... and the **COSTS** with the

# surfindicator

No over-finishing . . . no under-finishing with the Brush Surfindicator. Weighing only 15 lbs. and ready to be plugged into any 115 volt outlet, it provides on-the-job instant surface measurement. Controlled finish is now practical—inexpensive—and extremely profitable.

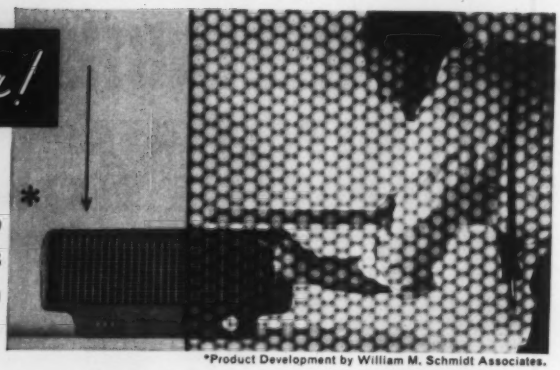
The Brush Surfindicator measures any surface—any shape—any size. Accurate measurements in microinches can be seen at a glance! It brings you laboratory-precision measurement unaffected by magnetic fields, vibration or line voltage variation. It requires no skill . . . can be used by anyone who can read a meter. Measurements are easily made in complete compliance with the new ASA and military standards. Write for the ASA standards and all of the complete facts on this profit-making tool that will pay for itself!

brush INSTRUMENTS
DIVISION OF CLEVITE CORPORATION
3405 PERKINS AVENUE CLEVELAND 14, OHIO

Circle 492 on Page 19

Idea!

mock-up projects design

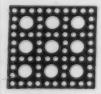


*Product Development by William M. Schmidt Associates.

with H & K perforated metals

A few of the thousands of H & K patterns are illustrated in reduced size

Send today to nearest H & K office for General Catalog



Here is an H & K perforated metal grille utilized in a mock-up of a record player. This greatly helps the Industrial Designer project his concepts as H & K perforated metal is now in its proper element for consideration of use and selection of pattern.

By referring to the H & K General Catalog, the designer can select one or more patterns for his project.

H & K perforated metals provide the Industrial Designer, and other men of ideas, a medium of unlimited opportunities for designing better and more attractive products.

THE Harrington & King PERFORATING CO. INC.

Chicago Office and Warehouse
5670 Fillmore Street
Chicago 44, Illinois

New York Office and Warehouse
114 Liberty Street, Dept. MD
New York, New York

Circle 490 on Page 19

RUGGED and RELIABLE

New!

TRANSISTORIZED

The A. W. HAYDON COMPANY'S TRANSISTORIZED SUB-MINIATURE ELECTRONIC TIME DELAY RELAYS!

SAVE SPACE AND WEIGHT!

| | Miniature Series | Sub-Miniature Series |
|---|---|---|
| Cross Section | 13/16" x 1 21/32" | 31/32" x 1 3/16" |
| Length | 2 1/4" long | 2" long |
| Weight | 6 ounces | 3 ounces |
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TEST-PROVED PERFORMANCE!
High Temperature: 125°C (250°F)
Vibration: 2000 CPS at 15 g.
Contact arrangements up to 4 pole double throw
Unique transistorized R.C. time constant network
Time Delays from 50 MS to 120 seconds. Longer Delays available
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MEET REQUIREMENTS OF MIL-E-5272A

The A.W. HAYDON Company

249 NORTH ELM STREET, WATERBURY 20, CONNECTICUT
Design and Manufacture of Electro-Mechanical Timing Devices

Circle 491 on Page 19


## HELPFUL LITERATURE

### Coated Steel Tubing

How designers can use coated steel tubing for parts and products is shown in Bulletin PO-5558. Properties of Zincgrip, Aluminized steel Type 1, and Type 2 are listed, and sizes and gages are recommended for typical products. 6 pages. Armco Steel Corp., 5558 Curtis St., Middletown, Ohio. G

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**CONTROL** the finish ... and the **COSTS** with the

# surfindicator

No over-finishing . . . no under-finishing with the Brush Surfindicator. Weighing only 15 lbs. and ready to be plugged into any 115 volt outlet, it provides on-the-job instant surface measurement. Controlled finish is now practical—inexpensive—and extremely profitable.

The Brush Surfindicator measures any surface—any shape—any size. Accurate measurements in microinches can be seen at a glance! It brings you laboratory-precision measurement unaffected by magnetic fields, vibration or line voltage variation. It requires no skill . . . can be used by anyone who can read a meter. Measurements are easily made in complete compliance with the new ASA and military standards. Write for the ASA standards and all of the complete facts on this profit-making tool that will pay for itself!

brush INSTRUMENTS
DIVISION OF
3405 PERKINS AVENUE CLEVITE CORPORATION CLEVELAND 14, OHIO

Circle 492 on Page 19

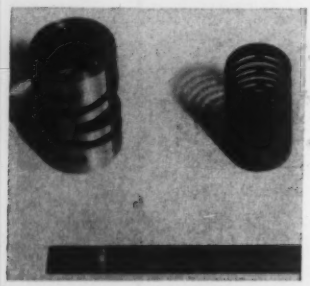
# New Parts and Materials

**Use Yellow Card, page 19, to obtain more information**

## *Machined Springs*

**for instrument and control applications**

Precision compression springs are designed for application in cases where conventional springs are inadequate, particularly in instruments and controls. Herringbone (left) and Gimbal (right) styles are both machined, heat treated, and ground to offer square ends, tight control of free length, and



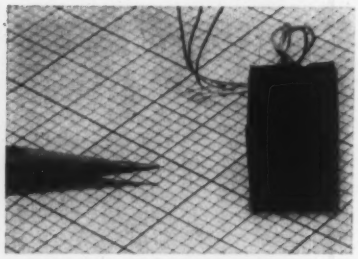
exact matching of specified spring rate. Construction eliminates twist or turning moment between end faces that can produce shifts. Springs offer uniformity of spring rate from zero load up, since effective length of turn does not change with load. Symmetrical application of force at diametrically opposite points effectively eliminates tendency to cock. Herringbone design, for equivalent characteristics, occupies less volume than Gimbal type. **Consolidated Controls Corp.**, Bethel, Conn. B

*Circle 645 on Page 19*

## *Magnetically Actuated Switch*

**withstands high impact stresses**

Magnaswitch is a magnetically actuated unit which requires no external physical contact. It handles linear or rotary applications. Completely encapsulated, switch is impervious to environmental contaminants and withstands high impact stresses without damage or malfunction. Unit can be actuated with either a permanent magnet or electromagnet. One actuator can be used to trip any number of switches. Push-pull, sliding, or rotary motion can be used. Capacity, dependent on application, is up to 15 amp, 250 v. **Reed Research Inc.**, 1048 Potomac St. NW., Washington 7, D. C. C

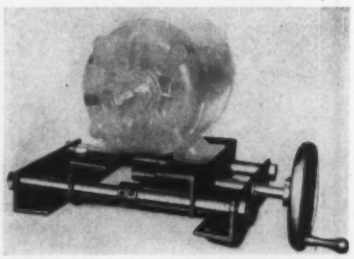


*Circle 646 on Page 19*

## *Small-Motor Bases*

**permit wide range of speed variation**

SB bases are for fractional-horsepower motors with variable-pitch sheaves. Model SB-2L permits 5 in. bed travel and Model SB-2S, 4 in. travel. Both have 4½-in. handwheel and screw adjustment with locknuts to limit movement, assuring positive settings without slippage. Rigid guide rods are provided for smooth, positive sliding action. Model SB-2L is 7½ in. wide by 17 in. long and handles ½, ¾, and 1-hp motors. Small



SB-2S base handles up to ⅓-hp motors. **Rampe Mfg. Co.**, 14915 Woodworth Ave., Cleveland, Ohio. G

*Circle 647 on Page 19*

## *Epoxy Resin*

**for high-temperature applications**

X-2638.3 epoxy novolac has applications in high-strength adhesives for metal fabricating, glass-reinforced laminates for structural shapes, and in electrical printed circuits. It is for all applications requiring resistance to high temperatures and great heat stability. Material exhibits greater strength at high temperatures, greater heat stability, and more chemical resistance than conventional epoxy resins. It is available also in an 85 per cent solids solution to facilitate handling by fabricators. **Dow Chemical Co.**, Midland, Mich. H

*Circle 648 on Page 19*

## *Nickel-Cadmium Cells*

**for subminiature units requiring minimum power**

Two rechargeable button cells of sintered-plate nickel-cadmium measure only ⅞ in. diam and weigh ¼ oz. Units, designed for miniature and subminiature electrical and electronic applications where minimum power is required, are maintenance-free. Nongassing upon recharge, they require no filling or electrolyte, operate at normal temperature

# Quietest Direct Drive Blower Motor

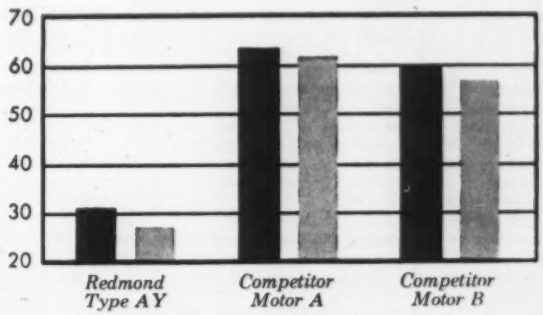
Place a mechanic's stethoscope on the end cap and you can easily hear the difference between the newly-designed Redmond Type AY and motors of conventional design. Try it on a Redmond 1/6 hp—the noise level is about that of a 1/35 hp motor of conventional design.

## New Redmond Design Reduces Blower Vibration to One-Fifth that of units using Conventional Shaded-Pole Motors

**Apply vibration tests** and you will be quick to agree that here is the quietest direct-drive blower motor available. The AY Tri-Flux motor is designed and manufactured in every way to give years of trouble-free service and whisper-quiet operation. The positive oil system provides force-feed lubrication. Recirculating the oil assures maximum bearing life.

**The graph shows vibration test results** on the new Redmond design and two competitive motors. These tests were made with the best vibration testing equipment available. The solid black bar shows vibration on the motor end cap; the gray bar shows vibration on the blower housing. The graph is decibel readings on 120 cycles, since the 120 cycle frequency is the one that is the basic source of nearly all noise problems. Reduction of vibration is a logarithmic function—the reduction of vibration in the Redmond motor to 33 decibels reduces noise to only 1/5th that of conventional motors.

**The new AY is ideal for a wide variety of applications requiring a whisper-quiet, economical, high-quality motor.** Contact us at Owosso, Michigan, and we will have the Redmond sales engineer in your district call you at once.

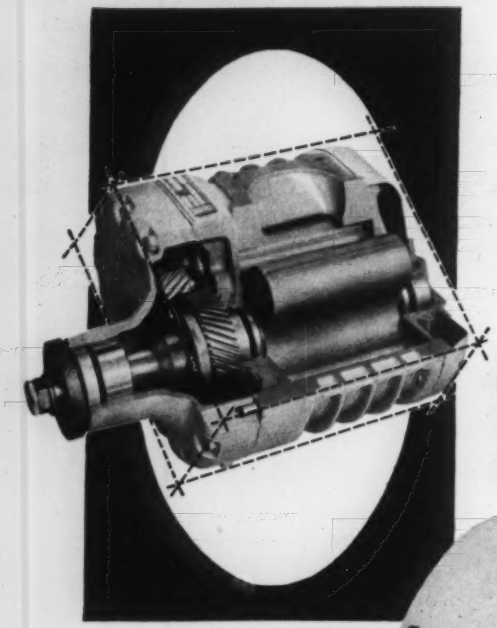



CC Redmond COMPANY, INC.

*The Standard of Dependability*

Subsidiary of CONTROLS COMPANY OF AMERICA

OWOSSO, MICHIGAN

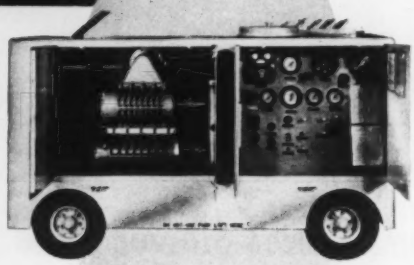


**delivers 1,000 cfm (up to 14 psig)**

**takes less than 5½ cu. ft.**

**Arnolt Corp. Model CPT6-O TESTER, PRESSURE CABIN LEAKAGE (For Military and Civilian Aircraft)**

Utilizes 2-stage M-D Blower Unit
1000 SCFM—10 PSIG
800 SCFM—12.5 PSIG
600 SCFM—14.0 PSIG

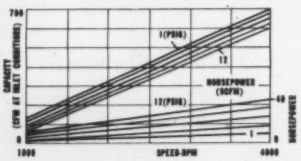


**ARNOLT CORPORATION FINDS M-D ROTARY POSITIVE BLOWERS USE LESS H.P.— EFFICIENT AT WIDE SPEED RANGE**

The Arnolt Corp. employs a 2-stage M-D blower in their cabin pressure leakage tester for several reasons. It does the job with 50% reserve capacity, takes up a fraction of the space of competitive blowers with equal capacity, operates efficiently at any speed or pressure and requires a smaller driver.

If space and weight of the blower is a concern in your design problem, consider this fact. M-D rotary positive blowers because of their unique 3-lobe design require smaller cubic space than any other blowers. A survey shows that a 10 PSI M-D takes ¾ to less than 1/10 the space of competitive models . . . and in some cases are only 1/10 the weight.

M-D Blowers operate at wider pressure and speed ranges than any other rotary positive blower. The capacity of the Model 4012 (4" rotor 12" long) is shown below. Capacities of 11 other production models range from 50 to 4000 CFM, pressures to 14 PSIG single, 70 PSIG multi-stage.




*For full information write*

**M-D BLOWERS, INC.,** RACINE, WISCONSIN

**A Subsidiary of Miehle-Goss-Dexter, Inc.**

**Circle 494 on Page 19**



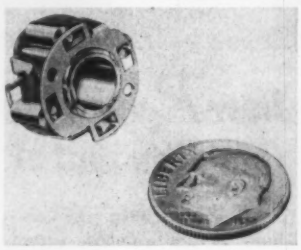

ranges, and have low internal resistance which allows discharge currents up to ten times capacity. Cells can be stacked into batteries and connected into series or parallel. Two ratings are 0.18 and 0.10 ma, both with open-circuit voltage of 1.2 v. Recharging requires constant current equal to 1/10 normal capacity. **Alkaline Battery Div., Gulton Industries Inc.,** 212 Durham Ave., Metuchen, N. J. D

**Circle 649 on Page 19**

## Miniature Clutches

**allow drive in one direction and free-wheeling in opposite**

Miniature one-way precision roller clutches meet requirements for near-zero backlash, free-wheeling, selective coupling, automatic cycling, dual or multiple drives, and infinitely adjustable ratchets. They allow drive in one direction and provide free-wheeling action in opposite direction. Basic assembly



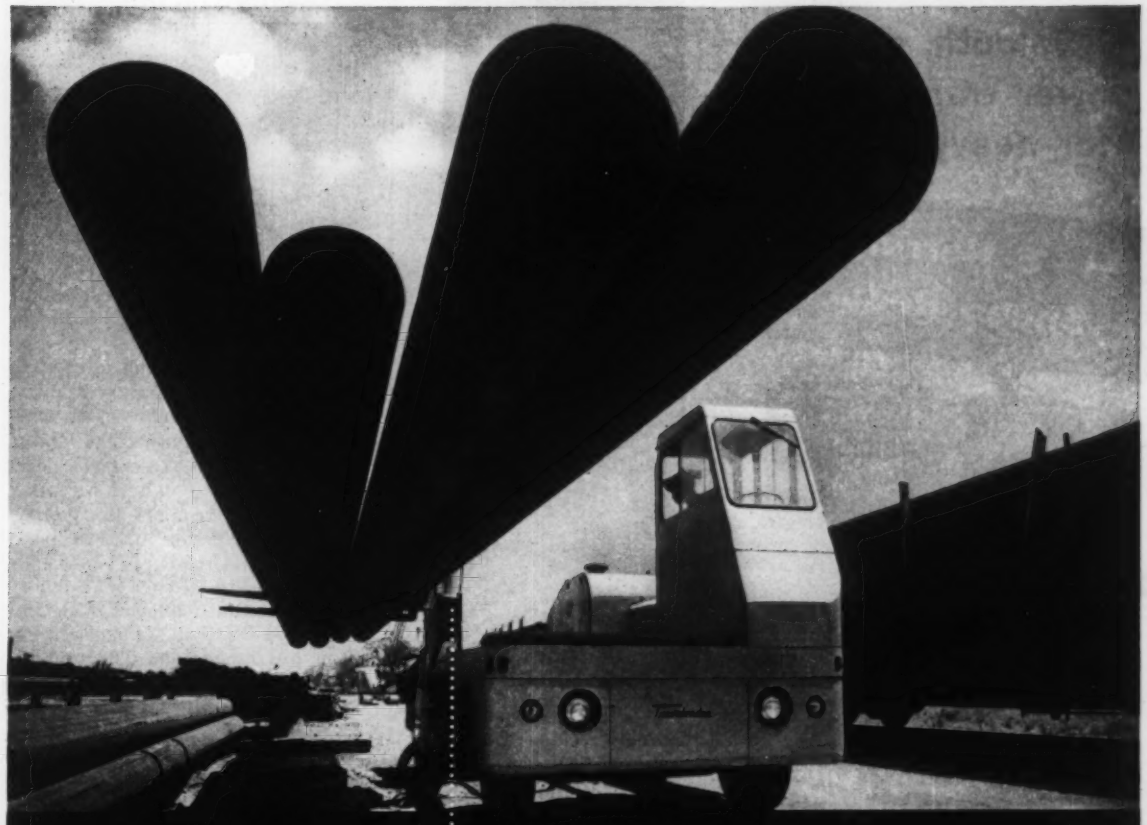
consists of a hardened and precision ground cam block, four bearing-steel rollers, four springs, and two side retainers, available in four sizes for installation in housing. Complete clutches, including housing and shaft, and precision ball bearings in some models, are also available. Roller assembly sizes range from 0.1875-in. bore and 0.625-in. OD through 0.625-in. bore and 1.625-in. OD. Right or left-hand drives are offered. **Miniclutch Co.,** 373 Morse St., Hamden, Conn. B

**Circle 650 on Page 19**

## Quick-Release Fastener

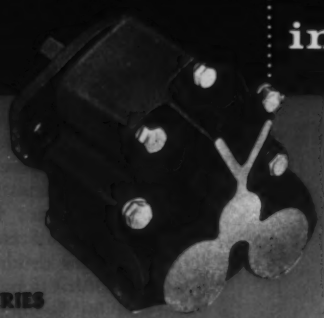
**is three-piece unit for panel thicknesses 0.62 to 1.87 in.**

Three-piece Pres-Loc slide fastener consists of receptacle, retaining ring, and preassembled stud nut. Stud



# DYNAMIC DIFFERENCE

## in hydraulic performance



**"HC" SERIES**

**POSITIVE DISPLACEMENT GEAR-TYPE PUMP**

Shaft seal: lip type
Drive: direct, gear or belt
Capacity: 5 sizes, 5 - 17 gpm
Pressures: to 1500 psi

Operating speeds: to 2400 rpm
Porting: side (Std.) end (Opt.)
Valve: Optional; internal relief, adjustable 800 - 1500 psi

BULLETIN HY1 gives complete engineering characteristics — performance and installation data.

***Call the man from Webster***

*. . . he's one of a staff of engineers, specially trained in hydraulic application. He can help you solve special problems when hydraulics become a part of your design!*

photo: Baker Industrial Trucks, div. of Otis Elevator Co., Cleveland, O.

# Webster

## POSITIVE DISPLACEMENT GEAR-TYPE PUMPS

Yesterday's pipe dream is today's nimble-fingered reality. This versatile fork lift truck unloads and stacks — carries a full platform load. The heart of its powerful hydraulic system is a Webster Gear-Type Pump. Just another example of Webster's practical and economical adaptation to hundreds of hydraulic applications . . in lift systems, pressure lubricating, oil circulating . . . in industrial, agricultural and construction equipment.

Webster Gear-Type Pumps present many advantages in design "fit" and application — with unusual standardization and interchangeability of components. Keep Webster in mind when you plan hydraulics — for the dynamic difference that pays!

OIL HYDRAULICS DIVISION

**WEBSTER ELECTRIC**

RACINE · WIS

our 50th year

franklin adv. H-113



Circle 495 on Page 19

## Smooth, quiet power transmission for heavy loads—

The Herringbone gear design provides continuous tooth action — eliminates end thrust.

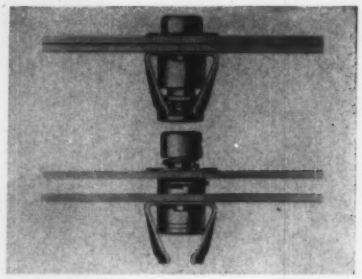
Built for heavy load conditions, Horsburgh & Scott Herringbone Speed Reducers give you dependable economical service. They're available in single, double and triple reduction units. Check these 9 points of superiority:

1. Overall design conforms to AGMA specifications.
2. All bearing loads are balanced, due to the symmetrical design of the gearing.
3. Oversize bearings and low speed shaft provide tremendous overhung load capacity.
4. Heavy wall and base-pad thickness provides extra housing rigidity.
5. Housing designed with box-type construction for maximum thermal capacity.
6. Every gear is accurately sized and then cut on a modern Sykes continuous tooth gear generator.
7. All pinions are integral with the shafts and are made of heat treated alloy forgings.
8. Dust and oil-proof seals are provided on shafts extending outside the housing.
9. Splash lubrication floods all bearings and gears.

You'll find a wealth of information in our Catalog 55 describing our complete line of Speed Reducers. Write for it, or ask your nearby H & S representative.

**THE HORSBURGH & SCOTT CO.**
**GEARS AND SPEED REDUCERS**
5112 Hamilton Avenue
Cleveland 14, Ohio



is inserted through panel to engage receptacle, and stud button is then pushed to lock assembly. To unlock, button is pushed to force spreader between receptacle leaf springs, permitting unit to be withdrawn. Unit requires no special tools for installation. Suited particularly for aircraft, missile, and electronic fields, fastener is available in steel in stud diameters of 0.386, 0.453, and 0.515 in. Panel thicknesses can range from 0.62 to 1.87 in. **Deutsch Fastener Corp.**, P. O. Box 61072, Los Angeles 61, Calif. L

*Circle 651 on Page 19*

### *Miniature Stepping Motor*

**high-speed unit prevents double indexing**

Miniature stepping motor and switch cannot double index during shock, vibration, or over-voltage. Two models of stepping devices, designated MotoStep and Motoswitch, are available in unidirectional and bidirectional units. The stepping switch is a ten-point etched-circuit, precision switch with plated contacts. The bidirectional feature is accomplished through use of two identical stepping motors driving same shaft in opposite directions. Output shaft is rotated 36 deg for each input impulse, up to 40 steps per sec. Both units are available in standard volt-

Circle 496 on Page 19

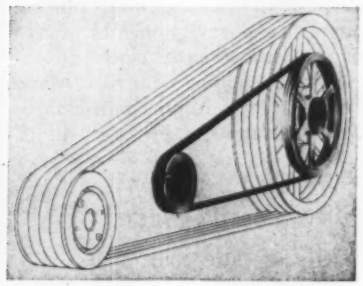
ages of 24, 48, and 90 v dc, and 110 v ac, with intermediate voltages also available. Applications include use in programming devices and for sequential operations where digital-to-analog information conversion must be made. **Data Instruments Div., Telecomputing Corp.**, 12838 Saticoy St., North Hollywood, Calif. L

*Circle 652 on Page 19*

## V-Belt Drive

**has narrower belts and sheaves than previous units**

Super HC V-belt drive provides complete coverage of entire range of drive requirements with only three cross sections instead of five. Drive has narrower, deeper cross-sectioned, high-capacity belts, and



narrower sheaves (shown), providing up to three times the horsepower capacity of previous units in the same space. Arched top of belt prevents distortion of tensile section, permitting each of the tensile cords to carry correct amount of load. Improved concave sidewalls eliminate concentrated wear on sides of belt and insure precision fit in groove for maximum pulling power. **Gates Rubber Co.**, 999 S. Broadway, Denver 17, Colo. K

*Circle 653 on Page 19*

## Pushbutton Switch

**has electronic circuit for single-pulse output**

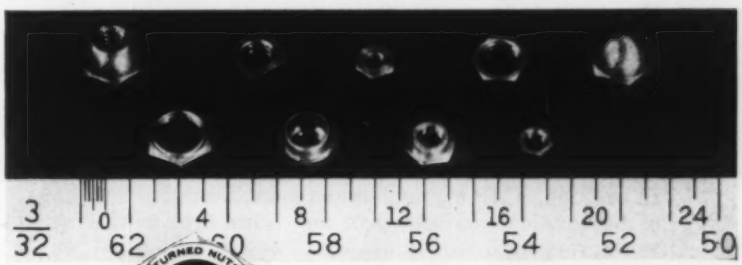
1PB600 series pushbutton-switch assemblies, which operate in −65 to 185 F temperatures, are designed for use in electronic test circuits, keyboard input consoles, fusing arming and firing circuits, and reflected pulse systems. They incorporate an electronic circuit to produce a single, micro-second-length pulse with each operation, eliminating

IT'S
THE
PROJECT
THAT
DETERMINES
THE
SIZE
OF
THE
FASTENER!

*Size is merely relative* . . . even in miniature nuts. The real criteria are uniform accuracy, dependable performance and prompt delivery at competitive prices.

As the leading producer of *turned* nuts . . . both standards and specials . . . Fischer can supply a complete range of precision nuts to solve fastening or assembly problems in all types of miniaturized equipment.

Whatever your application, let Fischer quote your next order for miniature or special nuts.




*This enlarged scale photograph illustrates typical miniature nuts being supplied for electrical and electronic products.*

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451 Morgan St., Cincinnati 6, Ohio
Please send 20-page CATALOG FS-1000 containing complete specifications on brass and aluminum nuts.

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Street_____
City_____ Zone____ State_____
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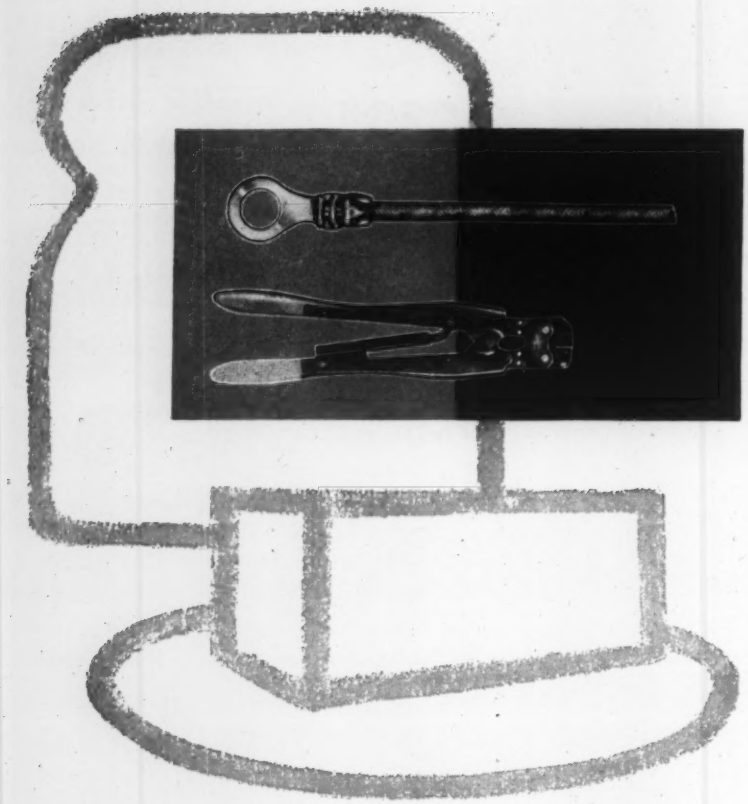
*Circle 497 on Page 19*



# A basic "bread and butter" team

Each A-MP terminal line and matching tool were designed to go together like bread and butter . . . and to be as basic to your electrical circuit termination program.

Reliability and lowest cost also go together like bread and butter in this A-MP tool and terminal method. There are no hidden "caviar" costs or doubtful connections. In fact, total installed cost is lower than any other terminal-attachment method, while the entire termination operation is mechanically quality-controlled to create the highest reliability in the finished product.

In addition, AMP manufactures a more diversified line of termination products than any other firm in the world, ranging from top quality circuit terminals and splices to versatile multi-circuit units for the most complex electronic components.

Here, truly, is a line that will earn its bread and butter in your plant day after day, year after year.

Write for more information on this modern, low cost circuit termination method.

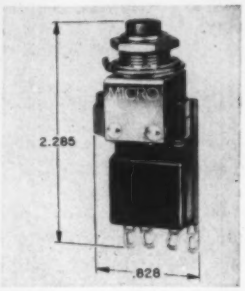
**AMP INCORPORATED**

**General Offices: Harrisburg, Pennsylvania**

A-MP products and engineering assistance are available through subsidiary companies in: Canada • England • France • Holland • Japan



need for special pulse-input circuits in high-speed electronic switching devices. Square-wave pulse width is factory adjustable from 0.2 to 2.5 mu sec, and amplitude from 3 to 60 v. Both width and amplitude are independent of speed of switch operation. Circuit includes ca-



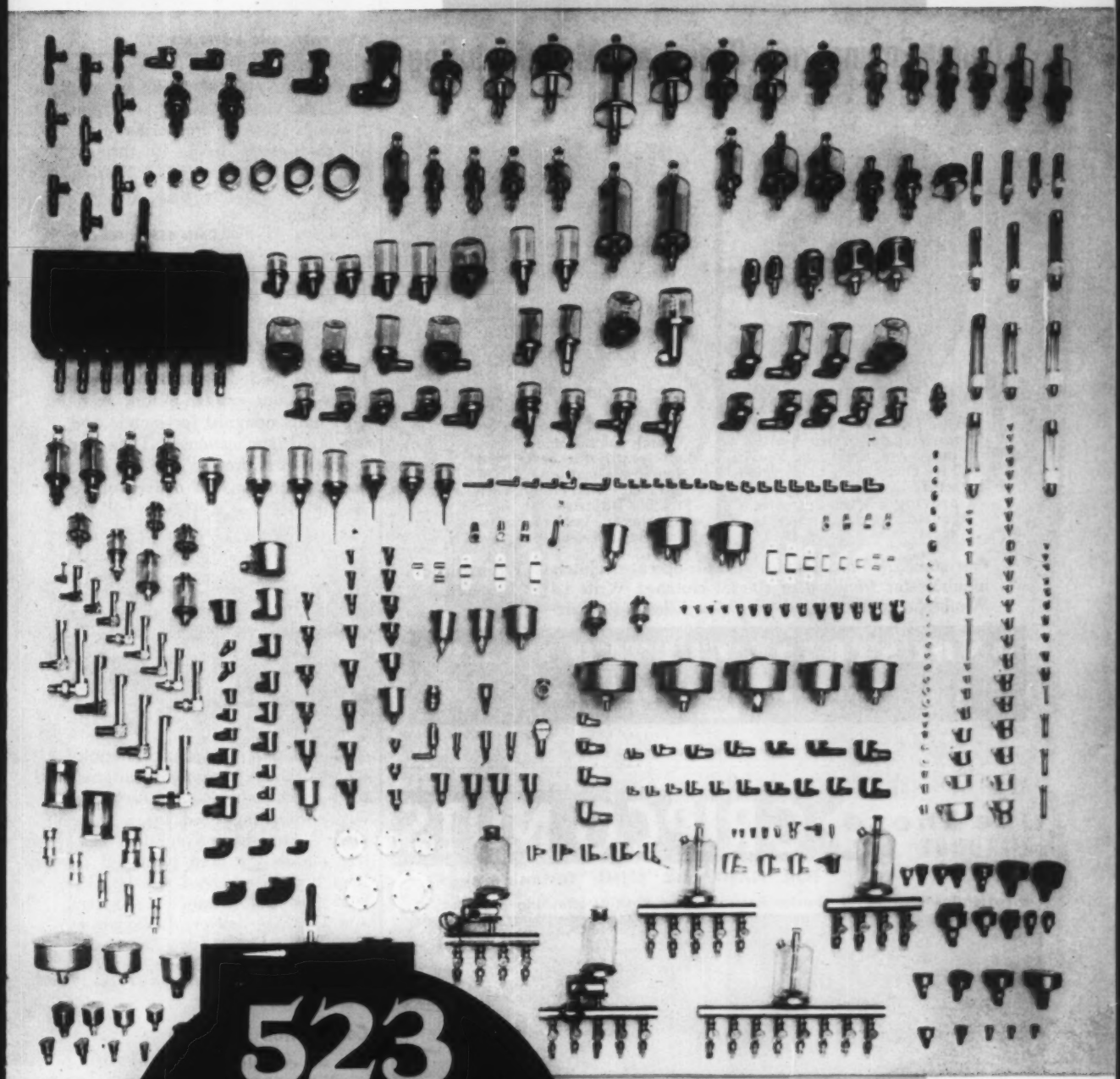

pacitor, resistor, magnetic core, and diode. Components are potted in a modular package to provide physical and environmental protection. Contact arrangement is single - pole, double - throw. **Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.** K

*Circle 654 on Page 19*

## *Pillow-Block Bearings*

**have shock-resistant, ductile housings**

Pillow-block (top) and flange bearings are low-cost units which carry light loads at normal speeds. They have durable housings of ductile material that resists shock and vibration. Bearings incorporate an extended inner ring, two set screws for locking bearing to shaft, and elongated bolt holes for mounting. Other construction features include compensation for normal shaft misalignment, factory lubrication, neoprene seals, and standard grease fitting for service requiring relubrication. Pillow-block units are available in shaft sizes from ½



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*Specialists in Lubricating Devices and Shaft Seals for Almost Half-A-Century*

## GITS BROS. MFG. CO.

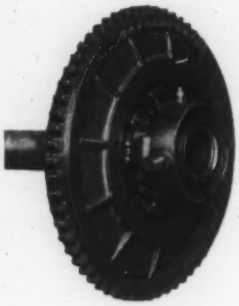
1868C S. Kilbourn Ave., Chicago 23, Ill.

Circle 499 on Page 19

# A Clutch Engineering, Design and Manufacturing

*Service For Industry*

Our Over-Center Clutches are available in Gear Tooth (as above), Solid Disc, and Flex-Disc types. Their five sets of over-center toggles provide 2-3 times greater bearing surface than is usual.



This Over-Center *Cut-off* Clutch has minimum over-all length for restricted space applications. All of our over-center clutches are readily adjusted for wear by releasing latch and turning toggle assembly.

Our standard line includes also air-operated clutches. We invite inquiries for *standard* or special clutches. Write us at Box 118, Waukesha, Wisconsin or telephone LIberty 7-3359.

**INDUSTRIAL CLUTCH CORP.**

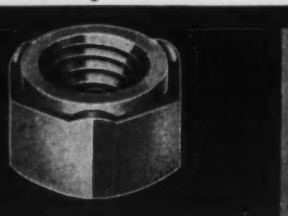
Waukesha Wisconsin

Circle 500 on Page 19

**Use These GRIPCO NUTS**

**FOR "FIXED" and "BLIND" fastening to get**

★ Easier Positioning ★ Quicker Fastening ★ Positive attaching ★ Less cost

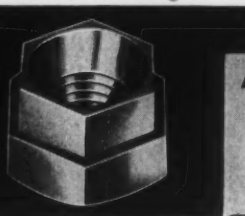


**GRIPCO PILOT-PROJECTION WELD NUT**

The centering pilot provides quick, easy positioning of nut in pre-punched hole for instant resistance welding. No jigs, no fumbling, no waste of time. No fouling of threads. In two pilot and projection heights with or without the Gripco Locking feature. Sizes No. 6 thru ⅜".

**GRIPCO COUNTERSUNK WELD NUT**

Countersunk feature eliminates time-wasting re-tapping of nut after welding. The 3 weld projections on both type nuts provide a firm non-rocking electrical connection.



**GRIPCO CLINCH NUTS**

With or without Gripco locking feature, for positive attaching of a threaded medium to thin metals. Can be automatically fed and clinched or staked with hydraulic or air equipment.

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ALL GRIPCO FASTENERS AVAILABLE FOR IMMEDIATE DELIVERY

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Ad No. 122

Circle 501 on Page 19



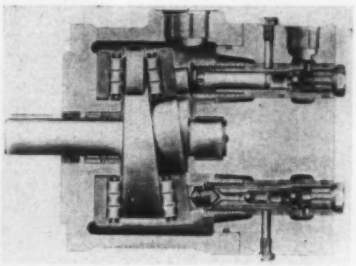

through 1 3/16 in. Units are also available with heavy, cast-iron housings (bottom) for normal duty, in shaft sizes from ¾ through 2 15/16 in. **Hoover Ball & Bearing Co.**, 5400 S. State Rd., Ann Arbor, Mich. H

Circle 655 on Page 19

## Hydraulic Piston Pumps

**incorporate internal inlet check valve**

PF 3021 and PF 6015 hydraulic piston pumps are ten-piston, axial-type units designed for mobile and industrial applications. They are for rated pressures to 3000 and 6000 psi respectively, and deliver up to



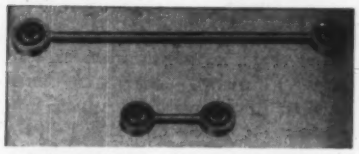
43.0 and 50.7 hp (peak intermittent). Pumps incorporate internal inlet check valve within each piston, eliminating need for a valve plate. Straight-line oil-flow pattern affords low noise level and allows high operational speeds. PF 6015 delivers 10.5 gpm at 1800 rpm, and PF 3021 delivers 14.7 gpm at 1800 rpm. **Dynex Inc.**, 777 Dynex Drive, Pewaukee, Wis. K

Circle 656 on Page 19

## Control-Rod Assembly

**is self-contained, self-lubricated unit**

Series C-100-A Alinabal control-rod assembly is for applications where a fixed nonadjustable center distance between joints can be used. The self-contained control rod is of welded construction. Two end rings are welded to control rod with a 125,000-psi welding rod, resulting in strength equal to a solid joint. Spherical race which retains self-aligning balls assures long cycling life at either high or low velocity. It will not flare out under these conditions, plus load, or high-frequency vibration. Sintered-metal,



oil-impregnated ball is self-lubricated, and is available in either bronze or iron-copper. Balls of other materials are also furnished, such as sintered nylon for high vibration, various types of stainless for corrosion resistance, and hot-work tool steels for high heat conditions. **Carter Engineering Co.**, Ferrysburg, Mich. H

*Circle 657 on Page 19*

### *High-Temperature Material*

**for sleeve bearing and seal applications**

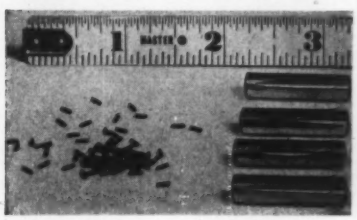
Clevite 300 has excellent antifriction properties, low wear rate, and thermal stability in light to moderate-duty continuous service at temperatures to 1200 F. In short-life applications it is effective at considerably higher temperatures. It also has shown promise in applications where lubrication cannot be provided. Designed for sleeve bearing and seal applications, the iron-base metallic compound is fabricated by powder-metallurgy techniques. Material runs best against itself, but can also be used satisfactorily in combination with commercial materials such as 52100 steel. **Cleveland Graphite Bronze Div., Clevite Corp.**, 17000 St. Clair Ave., Cleveland, Ohio. G

*Circle 658 on Page 19*

### *Miniature Locking Pins*

**of chrome-vanadium or stainless steel**

Groov-Pin locking drive pins are only 1/32 in. diam and ⅛ to ½ in. long. They are suitable for connecting or locking together two miniature parts, and can be used



*This can't be* FIREBAN...

**New Taylor FIREBAN 321 Laminated Plastic is self-extinguishing in only 3 seconds**

Electrical faults in appliances, TV sets, radios, motors and other electrical devices frequently lead to fires—and these fires lead to complete destruction of the equipment, sometimes extensive damage to the facilities surrounding it. Taylor FIREBAN 321 is designed to retard fire. Self-extinguishing in only 3 seconds—it is an effective barrier against the spread of flame. In addition, this flame-retardant laminated plastic has excellent moisture resistance, excellent electrical resistance after exposure to high humidity, and good mechanical properties; also offers low dielectric losses. These properties help prevent the electrical faults that lead to fires. Write TAYLOR FIBRE CO., Norristown 47, Pa., for complete details.

Taylor

LAMINATED PLASTICS VULCANIZED FIBRE

*Circle 502 on Page 19*

to replace plain pins or bent-wire fasteners. Miniature pins (left) have grooves similar to standard pins (right). Manufactured of 6150 chrome-vanadium or stainless steel 303, pins are held within tolerances of ±0.001 in. **Groov-Pin Corp.**, 1125 Hendricks Causeway, Ridgefield, N. J. D

*Circle 659 on Page 19*

## *Miniature Potentiometer*

**is offered in ranges from 10 to 75,000 ohms**

Model 550 three-turn precision wire-wound potentiometer, with only ⅞ in. diam, features precision ball or sleeve bearing mounts at both shaft ends, and machined aluminum lids for bushing or servo-type mounting. Body is moisture-proof laminated phenolic, which provides maximum dimensional stability and insulation resistance. Up to ten extra terminals can be added in addition to standard terminals to meet nearly all specified requirements. Unit is offered in ranges

from 10 to 75,000 ohms with linearity tolerance of ±0.3 per cent standard, ±0.1 per cent special. **Spectrol Electronics Corp.**, 1704 S. Del Mar Ave., San Gabriel, Calif. M

*Circle 660 on Page 19*

## *Bearing Materials*

**of filled virgin Teflon powder**

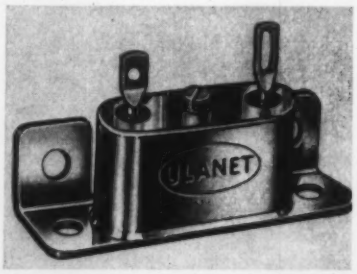
Seven filled Teflon bearing materials have excellent wearing qualities and are less subject to thermal expansion and cold flow than pure Teflon. They consist of virgin Teflon powder filled with various materials to meet specific operating conditions. Teflon fillers include glass, carbon, glass and carbon, ceramic, graphite and zircon, molybdenum disulphide and glass, and mica and glass. Applications include bearings, spacers, bushings, piston rings, inserts, connectors, and bases. Finished bearings, semi-finished moldings for finish machining, or stock material in tubing and rod forms are furnished. **Chemical & Power Products Inc.**, 11 Broadway, New York 4, N. Y. D

*Circle 661 on Page 19*

## *Miniature Thermostat*

**controls noninductive loads to 5 amp at 115 v ac**

Hermetically sealed miniature thermostat meets aircraft and missile requirements of extreme sensitivity to rapid temperature changes. It con-



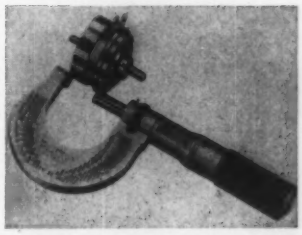
trols noninductive loads up to 5 amp at 115 v ac; for dc, a suitable condenser must be connected across terminals. Direct metal contact between 90-deg mounting bracket and thermosensitive element reduces heat path. Temperature differential is less than 1 F between −100 and 300 F. Additional features include strain-relief construction to prevent calibration drifts, and compression glass-sealed insulated terminals. Thermostat is available either precalibrated to a specific temperature with adjustment screw sealed, or with unsealed screw for experimental use. Size is 1.3 x 0.594 x 0.375 in. **George Ulanet Co.**, 413 Market St., Newark 5, N. J. D

*Circle 662 on Page 19*

## *Brake-Clutch*

**miniature unit is for close-coupled applications**

Pancake PMC-8 miniature electromagnetic brake-clutch is 0.5 in. long from servo flange to end of cap. It is used for close-coupled applications where high performance, fast response, reliability, and



low inertia are desired. Minimum-torque clutch or brake of 6 oz-in. capacity will not drop a load below 2.5 oz-in. minimum while switching from brake to clutch. Power consumption is 4.5 w, and response is 8 millisec. Unit has impregnated and encapsulated coils, zero backlash, no slip ring requirement, and zero end play. It is vibration, temperature, and attitudeproof per MIL-E-5272A, all procedures. **Autotronics Inc.**, Dept. 18, Box 208, Florissant, Mo. I

*Circle 663 on Page 19*

## *O-Ring Seals*

**for high-temperature hydraulic service**

O-ring seals are made from Compound N-304-7, a synthetic rubber material which meets physical and functional requirements of MIL-P-25732 (ASG). O-rings, available in all standard sizes, are suitable for temperature range of −65 to 275 F. Seals are available in MS-28775 series for military aircraft usage. **Parker Seal Co., Div., Parker-Hannifin Corp.**, 17325 Euclid Ave., Cleveland 12, Ohio. F

*Circle 664 on Page 19*

## *In-Line Relief Valve*

**for pressures to 5000 psi**

New in-line relief valve without breaking line is designed primarily for high-pressure, high-flow, and high-temperature applications. It is furnished in pressure ranges up to 5000 psi. Adjustment over entire range can be made by turning external adjusting nuts, without disconnecting either pressure

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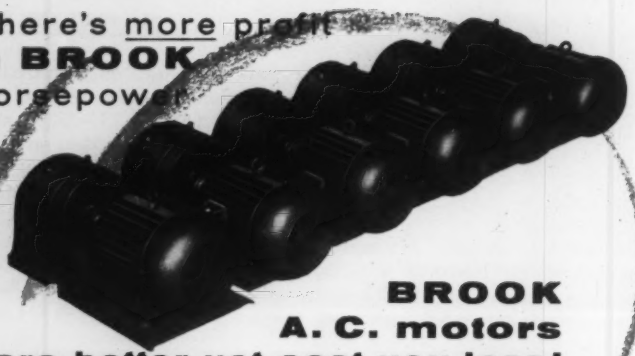
There is nothing like Teflon flexible hose for tough applications. Now, for the first time, you get "finger flexibility" in large diameters up to four inches with Springfield "400" . . . an exclusive new development by Titeflex. Short bend radius, long lengths, plus "Zero Motion Braid" make Titeflex Springfield "400" the big news in Teflon hose. Write for complete information, Bulletin 400.

*Circle 503 on Page 19*

There's more profit in BROOK horsepower



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are better yet cost you less!

Under the Brook O.E.M. Plan you get a better motor to power your product or equipment—yet, this superior motor which ranks with the best under any acceptable standards, actually costs you less than a second rate motor. This saving can be passed along to your customer — if you prefer — thereby lowering the selling price of your product. Everybody benefits! Ask about the BROOK O.E.M. PLAN and what other equipment builders are doing with Brook Motors.

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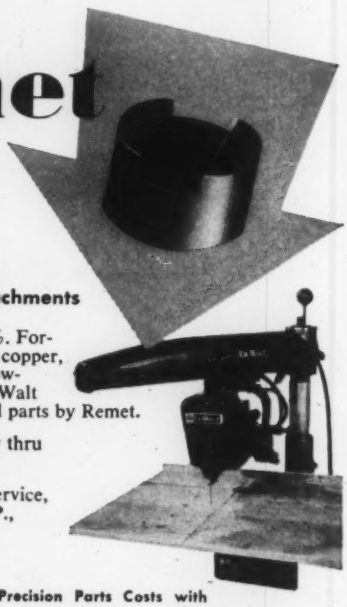
Circle 504 on Page 19

11 Remet
POWDERED METAL PARTS
now go into
DEWALT POWER SAW
and attachments



- This Remet collar reduced part cost 80%. Formerly a precision casting in beryllium copper, it is now a Remet copper infiltrated powdered iron part. Advantages led to DeWalt specifying 11 different powdered metal parts by Remet.
- DeWalt now offers greater saw accuracy thru maintenance of closer tolerances.
- "You can depend on Remet for better service, fast delivery," states A. C. Wedge, V.P., Mfg., DeWalt Div., American Machine & Foundry Company.

FREE, NEW BROCHURE "How to Cut Precision Parts Costs with the Remet Powdered Metal Process" gives complete information.
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"Oilless" Bearings • Bushings • Machine and Structural Parts in
COPPER • BRASS • IRON • ALLOY STEEL • NICKEL SILVER • COPPER INFILTRATED IRON

Circle 505 on Page 19

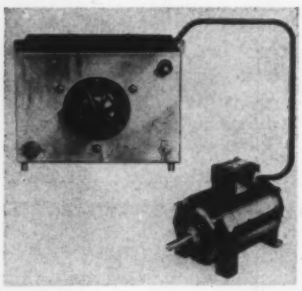


or return line. Unit provides free flow in reverse direction. Pilot operation provides for high flow capacity. Entire unit contains only one packing, an O-ring which can be replaced without taking valve out of line. Valve is available with either standard 37-deg flare or flareless fittings, in accordance with MS 33656 or MS 33514, respectively. Of stainless-steel construction, it has temperature range of − 65 to 160 F. Use of a special O-ring increases range to 400 F. Valve is available in tube sizes 8 and 12. **Republic Mfg. Co.**, 15655 Brookpark Rd., Cleveland 35, Ohio. G

Circle 665 on Page 19

## Adjustable-Speed Drives

**17 models have ratings from 1/20 to ¾ hp**



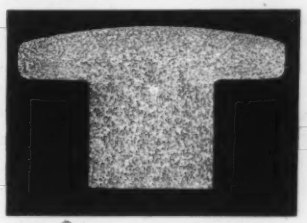
Motorformer adjustable-speed drives provide smooth control from zero to maximum rated speed. Conservative rating of silicon rectifiers and motors assures continuous operation at any speed. Entire controlled rectifier is contained in a compact enclosure designed for either bench use or wall mounting. Seventeen models have ratings from 1/20 to ¾ hp. Also available is a ½-hp unit with ungeared motor. **Servo-Tek Products Co.**, 1086 Goffle Rd., Hawthorne, N. J. D

Circle 666 on Page 19

## Electrical Contact Rivets

**are cold headed from silver-cadmium oxide wire**

Designated No. 710, electrical contact rivets are for heavy-duty applications where high electric conductivity, high resistance to sticking and welding, and good resistance to arc erosion are required. Advantages of the cold-headed contacts



include uniform dispersion of cadmium oxide throughout silver matrix, uniform electrical conductivity for all parts and batches, and uniform ductility. Electrical conductivity of the material is from 6 to 12 per cent higher than that of oxidized type and about 15 per cent higher than conductivity of pressed and sintered type. **Judson L. Thomson Mfg. Co.**, Sawyer Road, Waltham, Mass. B

*Circle 667 on Page 19*

### *Plastic Laminate*

**paper-base material is flame retardant**

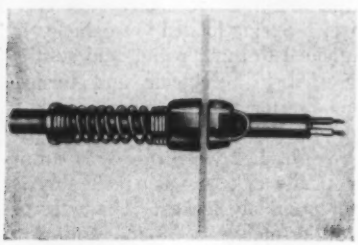
Fireban 321 is a paper-base plastic laminate which has high insulation resistance, low dielectric losses, low water absorption, good fabricating qualities, and is self-extinguishing within 3 sec after being set afire. Laminate is essentially a grade XXXP made with special phenolic resin. It is available in sheets of approximately 49 x 49 in. and thicknesses from 0.02 to ¼ in. thick. Color is maroon, and finish is semi-gloss. **Taylor Fibre Co.**, Norristown, Pa. E

*Circle 668 on Page 19*

### *Strain-Relief Bushing*

**for SJ wires and heavy-duty heater cord**

Model 6S-1 nylon strain-relief bushing is especially useful with heavy-duty heating appliances, portable electric tools, and household cleaners. Positive wire grip and nylon in-



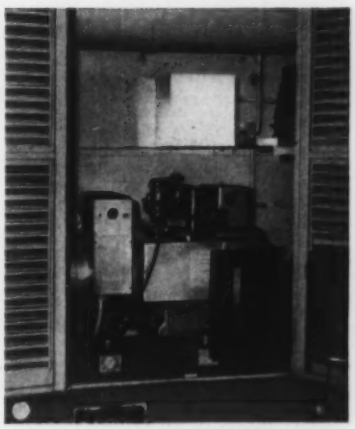

# Onan NEWS REPORT

## How to provide electric power for ice cream stores that move!

***Mister Softee* mobile ice cream vans** are as fully electrified as a store with utility connections. Ice Cream freezers, air conditioner, lights, fans . . . even the heater that keeps "Hot Fudge" hot are operated by electric power.

The Onan 10KW electric plant supplies all current required with a generous reserve for future electrical loads. It is mounted at the rear of the truck in an easily accessible compartment. Onan's Vacu-Flo cooling keeps the compartment ventilated . . . delivers all heated air to the outside. Over 300 of these Mister Softee vans are now in operation.

Where you need electric power on mobile units . . . an Onan electric plant will provide service with dependability approaching that of the electric utility. 500 to 200,000-watt models. Gasoline or Diesel.



Onan 10KW, CW Series plant shows simple, accessible installation. Two-cylinder, gasoline engine is smooth-running and quiet.

*Need specific information for your particular job?*

*Call the Onan distributor listed in your phone book or write direct.*

**D. W. ONAN & SONS INC.**

3009 University Ave. S.E., Minneapolis 14, Minnesota

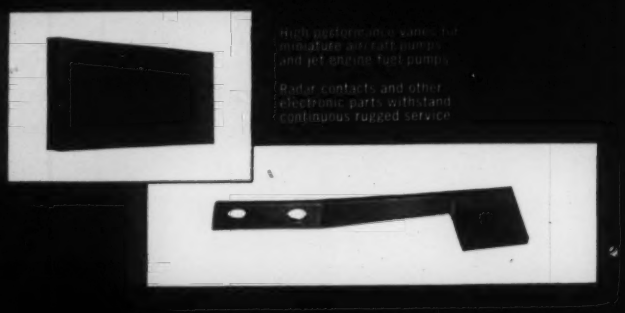
ELECTRIC PLANTS • AIR-COOLED ENGINES • KAB KOOLER • GENERATORS

Onan ELECTRIC PLANTS




*Circle 506 on Page 19*

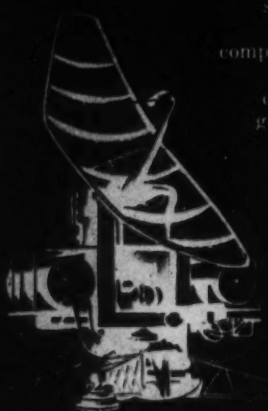
New applications


High performance vanes for miniature aircraft pumps and jet engine fuel pumps
Radar contacts and other electronic parts withstand continuous rugged service

–for self-lubricating

MORGANITE

Morganite components provide complete reliability in many types of airborne equipment. Morganite will not warp, stick or gum, is self-lubricating, non-contaminating. These dependable components function in high temperature and pressures and are unaffected by corrosive chemicals, oil, water, gases, grime . . . the standard of performance on process equipment, compressors, meters, pipe line and general industrial machinery.



For trouble-free operation — Install Morganite bearings, seal noses, pistons, piston rings, rod packings, gland rings, slides, valves and special parts. Call or write today for recommendations on specific applications.

Morganite INCORPORATED . . FOR OVER HALF A CENTURY

3314 48th Avenue
Long Island City 1, N.Y.

Manufacturers of Fine Carbon Graphite Products including Mechanical Carbons, Motor and Generator Brushes, Carbon Piles, Current Collectors and Electrical Contacts
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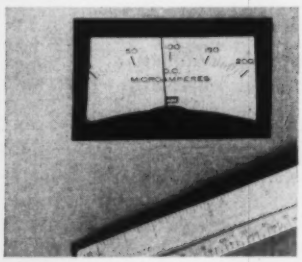
sulation protect wire from heat, vibration, pull, and torque. Spring which locks securely into bushing prevents sharp right-angle bending, excessive wire flexing, and chafing at chassis entrance. Unit is hinged with flexible nylon web, and is easily snapped and locked in chassis hole. **Heyman Mfg. Co.**, 100 Michigan Ave., Kenilworth, N. J. D

*Circle 669 on Page 19*

## Panel Meter

**has sensitivity ranges of 0-5 mu amp to 0-50 amp**

Model 361 panel meter occupies panel space of only 3½ x 2 in. and projects only 3/16 in. It exposes only the indicating area, with remainder of meter fitting behind panel. Dial and window are slanted for easy reading and can be il-



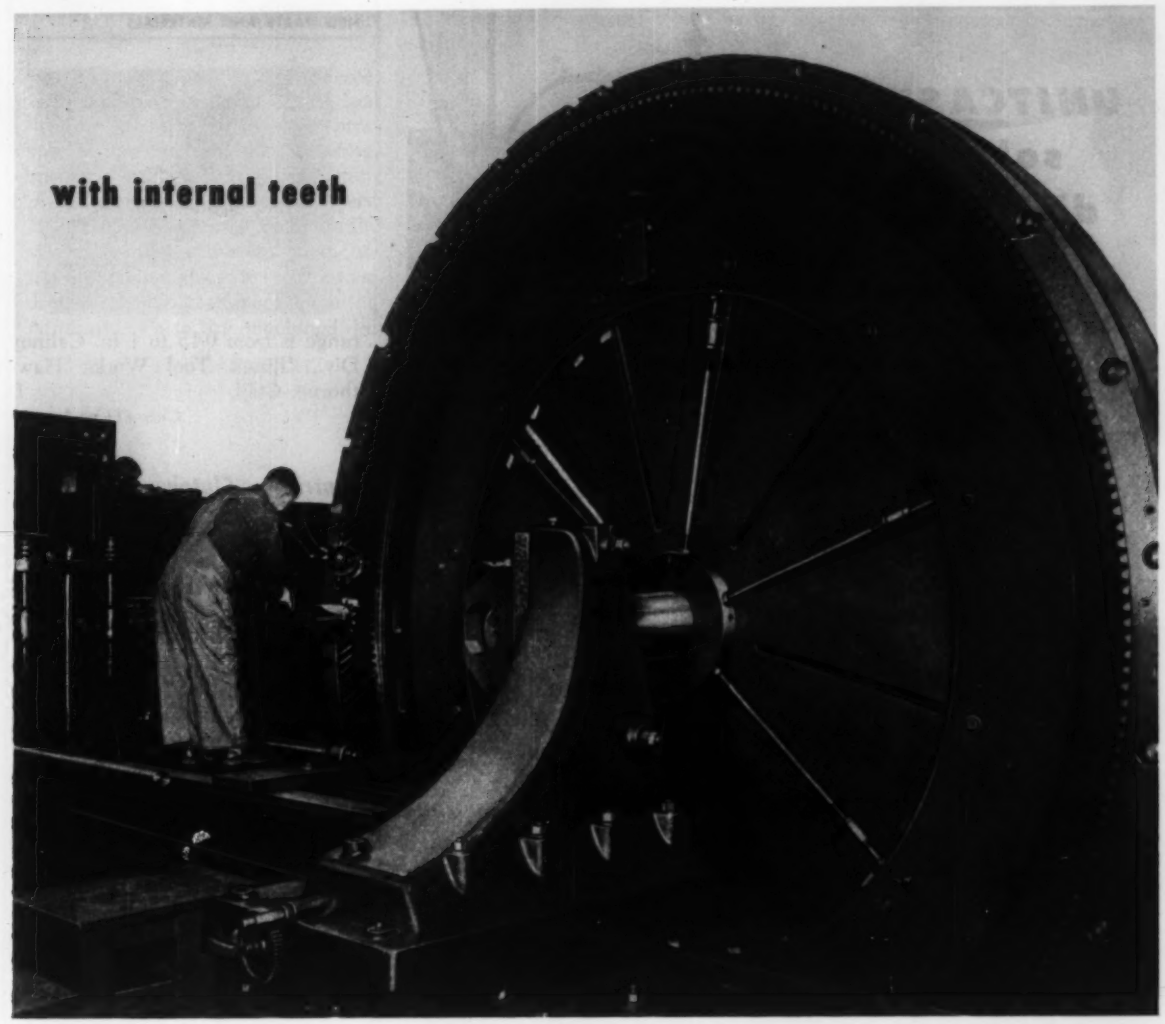

luminated through translucent rear window. Sensitivity ranges are 0-5 mu amp to 0-50 amp, and 0-5 mv to 0-500 v. Meter slips through rectangular panel hole and is held in place by rear screw-on clamps. It requires no positioning holes for mounting studs. **Assembly Products Inc.**, Chesterland, Ohio. F

*Circle 670 on Page 19*

## Quick-Release Fastener

**is high-strength, lightweight unit**

Two-piece steel quarter-turn panel fastener consists of a stud assembly and floating receptacle unit. Stud is inserted through outer panel, and grommet retainer makes stud captive. Spring-loaded receptacle is attached to inner panel, and stud is inserted in receptacle and turned one-quarter turn to become locked in place. Stud of the high-strength, lightweight unit is automatically ejected when assembly is not positively locked. Diameter of stud assembly is ⅜ in., and grip




*When designs include* **GIANT INDUSTRIAL GEARS**

**Specify Farrel** for accuracy, high quality and fine workmanship.

For 35 years the company's Buffalo plant has specialized in the production of large gears for various industrial uses. Here eight of the world's largest gear generators are kept in regular use. The precision inherent in the operating principle of these Farrel-Sykes machines provides accurate tooth spacing, profile and helix angle.

Farrel internal gears are available with single helical or spur teeth in sizes up to 23′ 0″ external blank diameter, 20″ face, ¾ DP. Farrel's continuous-tooth herringbone gears come in any size up to 23′ 0″ diameter, 60″ face, ¾ DP.

Ask for details of large industrial gears to meet your specific requirements.

**FARREL-BIRMINGHAM COMPANY, INC.**

**ANSONIA, CONNECTICUT**

*Plants:* Ansonia and Derby, Conn., Buffalo and Rochester, N. Y. • *Sales Offices:* Ansonia, Buffalo, Boston, Akron, Ann Arbor (Mich.), Chicago, Minneapolis, Los Angeles, Salt Lake City, Tulsa, Houston, Fayetteville (N.C.) • *European Office:* Piazza della Republica 32, Milano, Italy

*Farrel-Birmingham* ®

FB-1158



Circle 508 on Page 19

**Foundry Engineering aids product development!**

This steel casting is another example of Unitcast's ability to cope with unusual problems. As the main body of a new-type Pulsation Dampener for The National Supply Company's oil field equipment, this casting had many tough end-use requirements. Basically, the part had to absorb shock, withstand corrosion, and hold hydrostatic test pressures up to 8,000 psi. The fewer the components in the part, the better the durability.

The ideal solution, a one-piece steel casting, required accurate suspension of a huge core on a minimum number of points to produce a horizontal "tank" within consistent tolerances. One subsequent finishing problem involved economically "sealing" the core suspension holes by a method that would hold up in end use—*plus* pass radiographic inspection!

Once again, Unitcast foundry engineering has helped a customer develop a new product for their well-known line. Why not call in Unitcast engineers on your product-development problems? Write today!

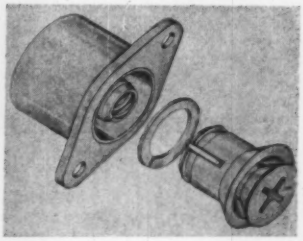
UNITCAST CORPORATION, Toledo 9, Ohio

*In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec*

**Unitcast**

**SPECIFICATION STEEL CASTINGS**



range is from 0.15 to 1 in. **Calinoy Div., Illinois Tool Works,** Hawthorne, Calif. L

*Circle 671 on Page 19*

## Centrifugal Clutch

**uses moderate camming or locking-in action**

Cam-type centrifugal clutch is designed for applications with high operating speeds or medium pulsating loads. It is suitable for electric motors or gasoline-engine applications where gradual engagement is required, or in operations starting from high inertia. Unit uses a moderate camming or locking-in action that permits it to disengage at approximately the same speed with which it engages, with or without load. Clutch is available in 1 to 30 lb-ft capacities, with rpm from 1200 to 3600. OD

is 4¼ in., with 7/16 to 1 in. diam bore. Clutch can be adapted to pulley, sprocket, gear, or coupling-type drive, mounted on either driving or driven member. **Magneto Div., Fairbanks, Morse & Co.,** Beloit, Wis. K

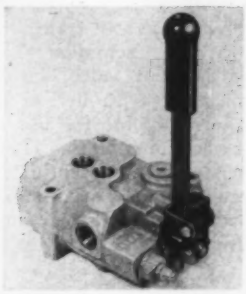
*Circle 672 on Page 19*

## Directional-Control Valves

**three models have ratings of 12, 20, 40 gpm**

One-spool hydraulic directional-control valves with handles, for general-purpose applications, have maximum working pressure of 2000

psi. Three capacities are offered, with nominal ratings of 12, 20, and 40 gpm. Valves provide low pressure drop and superior metering, ensuring smooth starting and stopping, or stepless control of speed in mechanism operated by hydraulic system. Integral check valve, externally adjustable, prevents load drop when changing spool operating positions. Ports are machined for



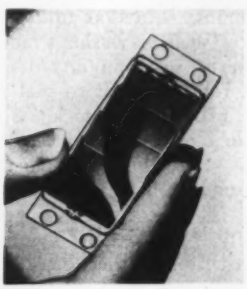
SAE straight-thread O-ring connections. **Parker Hydraulics Div., Parker-Hannifin Corp.**, 17325 Euclid Ave., Cleveland 12, Ohio. F

*Circle 673 on Page 19*

## *Silicon Solar-Cell Modules*

**supply 100 w power per 14 sq ft of cell area**

High-efficiency silicon solar converter modules are assemblies of series and parallel-connected silicon solar cells with contact strips that assure high conversion efficiency. Each module contains five series-connected 1 x 2-cm solar cells embedded in an epoxy mold that provides a rugged, shockproof, weatherproof housing. Modules supply 100 w of power per 14 sq ft of cell area, and convert up to 8 per cent of radiant energy falling on their surfaces. They can be used in conjunction with storage batteries to supply continuous power where unattended performance and long life



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ATLAS HAS THE CHAIN
FOR IT!
RUGGED BUILT...PRECISION FINISHED CHAIN, SPROCKETS, COUPLINGS
Whatever the product you have on the drawing boards or the production line if it requires extra quality roller chain Atlas can supply it. Single or multiple . . . regular or heavy duty . . . standard, extended pitch, special attachment or conveyor chain . . . steel, electrolized, stainless-steel or bronze . . . roller chain, sprockets and couplings.
Atlas makes them all to stand up and last longer on any drive. Atlas engineers are ready to supply you with the exact type of chain for the drive to provide maximum operating efficiency. For complete details and technical advice write to . . .
ATLAS CHAIN & MANUFACTURING CO.
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ATLAS
ROLLER CHAIN and SPROCKETS
DIVISION OF PRUDENTIAL INDUSTRIES, INC.




*Circle 510 on Page 19*

**10 to 100 times the wear resistance of other dry bearings**

**Comparative Thrust Washer† Performance**

| Type of Material | Mean Testing Time | Reason for Stopping |
|---|---|---|
| DU Composite | 1000 hrs. | Completed 1000 hrs. |
| T.F.E. in porous Bronze | 213 hrs. | .005" wear |
| Graphite & Lead Bronze | 158 hrs. | .010" wear |
| T.F.E. + 25% Graphite | 134 hrs. | .005" wear |
| Oil impregnated Bronze | 105 hrs. | .010" wear |
| Phenolic resin + $MoS_2$ | 73 hrs. | .005" wear |
| T.F.E. + 25% Glass fibre | 48 hrs. | .005" wear |
| $MoS_2$ Treated Steel | 26 hrs. | Seizure |
| Graphite (bearing grade) | 24 hrs. | .005" wear |
| Porous Bronze + $MoS_2$ | 17 hrs. | .005" wear |
| Asbestos + resin + $MoS_2$ | 0.8 hrs. | .005" wear |
| Nylon | 0.3 hrs. | .010" wear |

†*Thrust Washers used for comparative tests as most indicative of true relationship of values, since clearances do not enter into their performance.*

Compare performance and you will agree that DU—the patented steel-backed porous-bronze bearing with T.F.E.* fluorocarbon resin-lead—offers an entirely new conception of dry bearing service.

Consider its high compressive strength with no cold flow (51,000 psi.)—its extremely low friction with no slip-stick characteristics—its equally efficient performance at temperatures from −328° F to +536° F—its resistance to solvents, detergents, abrasive atmospheres—and you will find the answer to many difficult bearing problems where conventional lubrication is impractical or undesirable.

Ask your bearing manufacturer or write for engineering brochure to

SPECIAL PRODUCTS DEPT.
**United States Gasket Co.**
Camden 1, New Jersey

*TEFLON, *Du Pont Trademark*
*FLUON, I.C.I. Trademark*

**United States Gasket** *Plastics Division of* **GARLOCK**



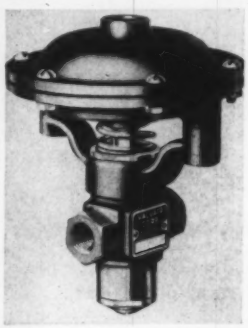

are desired, and can be interconnected in series-parallel configurations to supply any desired power rating. **International Rectifier Corp.**, 1521 E. Grand Ave., El Segundo, Calif. L

*Circle 674 on Page 19*

## Control Valves

**for 20 to 60-psi air actuation**

Diaphragm-operated control valves, designed for actuation by any three-way pilot valve, instrument control, cycle controller, or process timer, are suitable for use in air, oil, or vacuum circuits. They have neoprene-covered, synthetic-fabric diaphragms for maximum flexibility, resistance to oil, and high bursting strength. Valves are for



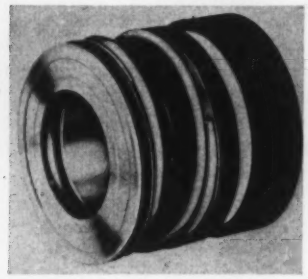
20 to 60 psi air actuation and 15 psi instrument pressure. They handle intermittent actuation pressures up to 125 psi. Complete range of mounting styles is furnished, with port sizes from ¼ through 1 in. NPT. **Valvair Corp.**, 454 Morgan Ave., Akron 11, Ohio. F

*Circle 675 on Page 19*

## Shaft Seal

**for 1, ⅝, and ¾-in rotating shaft**

Type H self-contained, compact seal is for use in jet water pumps, oil pumps, reduction units, or appliances such as washing machines. It can be used on any 1, ⅝, or ¾-in. rotating shaft to seal liquids that will not attack Buma-N flexible parts or brass metal parts. Face of seal, capable of withstanding high face loading and heat, is true carbon to prevent porosity. Seal can be mounted on a shaft from either direction. It



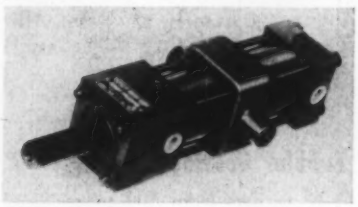
operates against pressures up to 75 psi, and has general operating limitation of 212 F with shaft speeds up to 1000 fpm. **Garlock Packing Co.**, 431 Main St., Palmyra, N. Y. F

*Circle 676 on Page 19*

### *Heavy-Duty Cylinders*

**for air and hydraulic service have one-piece trunnion**

Designed for all types of air and hydraulic applications, heavy-duty cylinders have pressure ratings of 200 psi air and 1000 psi hydraulic. Units feature positive adjustment and a one-piece trunnion, supported and positioned by four threaded cylinder tie rods. Trunnion is shifted by loosening tie-rod self-locking nuts to permit rotation of rods by solid hex ends. Rotation provides precise movement of trunnion to exact location desired. Full-diameter, full - strength cylinder tube has no weakening cuts or grooves and no distorting clamping pressure. Nine available bore sizes



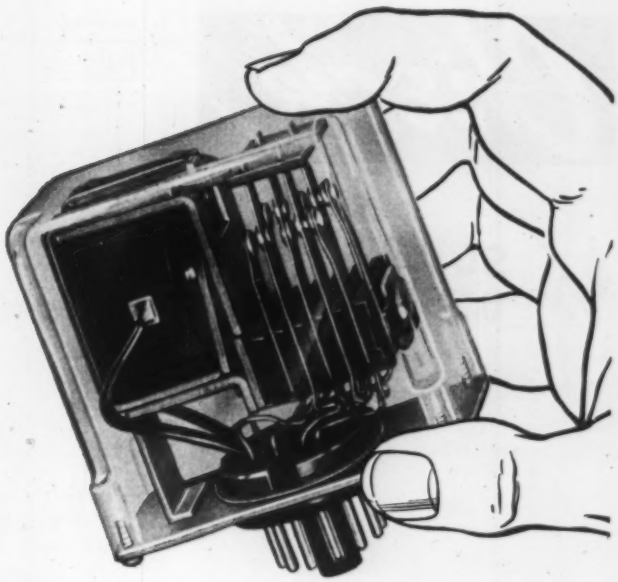
range from 1½ to 8 in., with strokes to specifications. Five mounting styles are furnished. **S-P Mfg. Corp.**, 30201 Aurora Rd., Solon, Ohio. G

*Circle 677 on Page 19*

### *Quick-Connect Fitting*

**has double end shut-off**

Swagelok quick-connect fitting for use on pneumatic or hydraulic lines has instant-acting seals in both parts of unit, preventing loss of any pressure from either end of line

NEW, LOW COST ANSWER TO

**"Over-Relayed" Industrial Controls**

S-D

**FRAME 219 RELAYS**

Stock types are DPDT on octal plugs; and DPDT plus two normally-open on 12-pin octal plugs. AC or DC operating coils.

Dimensions are 1 7/16" wide x 2 5/8" deep x 2 5/16" high exclusive of octal plugs.

Smaller, requiring less operating power and reasonably priced, Struthers-Dunn 219 Frame Relays are a big aid to economizing complex industrial panels that are often "over-relayed" with larger, more costly contactor-type control units than are actually needed.

Accepted standards of insulation include spacings of ⅛" through air; ¼" over surface, and a minimum of 1500 volts AC dielectric test. Other features are long life (20 million operations); plastic covers for good mechanical protection and easy servicing with plug-in construction. Contacts have 10 ampere current carrying capacity. Plug and socket combinations are the limiting factors on ratings.

Struthers-Dunn Bulletin 2219 giving full details is available on request.

**STRUTHERS-DUNN, Inc.**
Pitman, N. J.

Makers of the world's largest selection of relay types

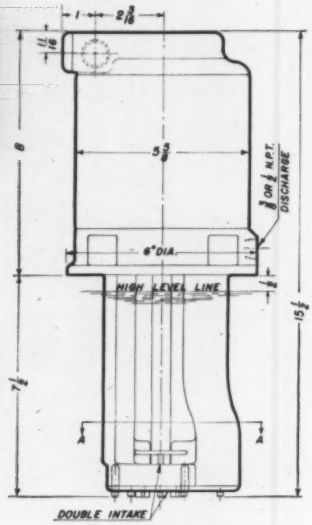
Sales Engineering Offices in: Atlanta • Boston • Buffalo • Chicago • Cincinnati Cleveland • Dallas • Dayton • Detroit • Kansas City • Los Angeles • Montreal • New Orleans • New York • Pittsburgh • St. Louis • San Francisco • Seattle • Toronto


*Circle 512 on Page 19*

# Check

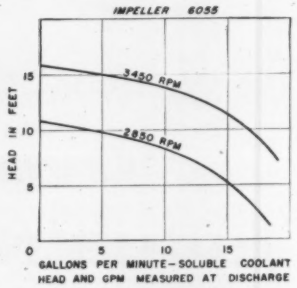
## ✓ SOUND DESIGN

Designed right, with all the experience that has made Ruthman Gusher Coolant Pumps the leader in their field, Baby Gushers are ideal for machines requiring a nominal volume of coolant.



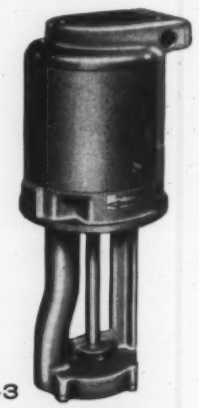

## ✓ ECONOMICAL PERFORMANCE

Your Baby Gusher will give you excellent and economical performance on your metal cutting equipment. Pumps up to 25 gallons per minute at 15 foot head. Uses less power when throttled—requires no priming. Coolant flow starts instantly.




## ✓ LONG LIFE AT MODERATE COST

The original cost of your Baby Gusher is moderate . . . maintenance cost is at an absolute minimum. Prelubricated ball bearings need no further attention. No packing or seals. There are fewer parts to wear. No metal to metal contact.



Model 6-P-3

IMMERSED TYPE

**You Get All 3 with a**

# BABY GUSHER

Other models of Baby Gusher and Tank Unit available.

Write for Catalog.

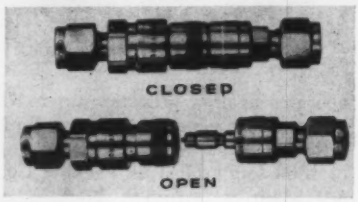
THE Ruthman MACHINERY CO.

- COOLANT PUMPS
- CIRCULATORS • AGITATORS
- MOLTEN METAL PUMPS

1811 Reading Road Cincinnati, Ohio




when fitting is disconnected. Flow is resumed instantly when male and female units are again connected. Finger-tip pull or push action is required for connection, and vacuum-tight pressure seal is assured when connection is made. Fitting is de-




signed for use with portable equipment and bulkhead or panel applications. It is available in steel, stainless steel, and brass, in sizes for ¼ through ⅜ in. OD tube. **Crawford Fitting Co.**, 884 E. 140th St., Cleveland 10, Ohio. G

*Circle 678 on Page 19*

## *Electric Motors*

**sleeve-bearing units use NEMA frames 180 and 210**

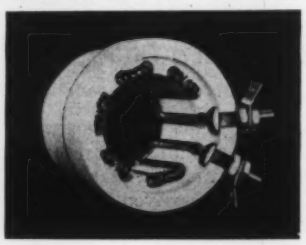
Type G dripproof, electric sleeve-bearing motors are recommended where quiet operation is desirable, such as in fan drives for heating, ventilating, and air-conditioning equipment, and for polishing and finishing machines, where vibration must be kept to a minimum. Units are available in NEMA frame series 180 and 210. Standard motor ratings range from ½ to 7½ hp. **Allis-Chalmers Mfg. Co.**, Milwaukee 1, Wis. K

*Circle 679 on Page 19*

## *Tubular Heating Element*

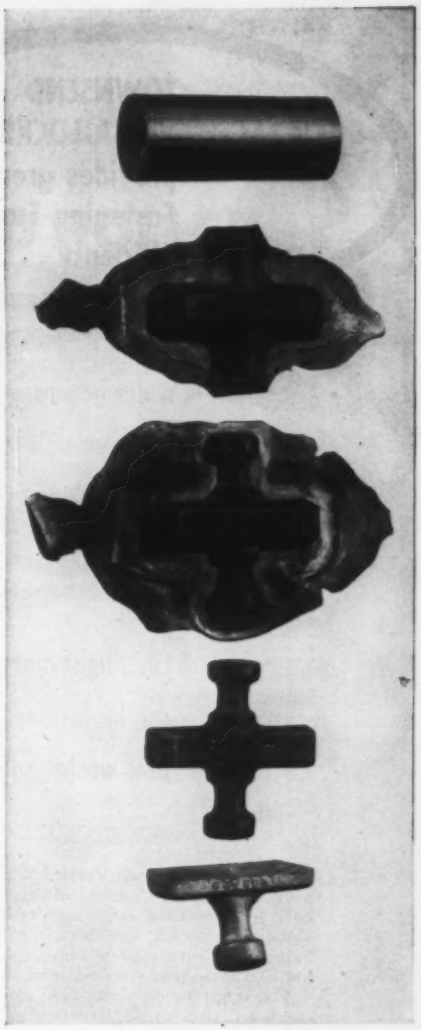
**in ratings from 500 to 2000 w at 115 v**

Tubular heating element is suitable for applications such as heat guns, hair dryers, space heaters, hot-food venders, photo-print dryers, and



for strength,
corrosion
resistance
and safety...

**it had to be Stainless**



*This window washer anchor is fabricated from Carpenter Stainless No. 4-A (Type 304) for use with window hardware on skyscrapers in large cities. Men attach their safety belts to these anchors while washing the windows. Stainless is used for maximum corrosion resistance and strength in atmospheric conditions. In fabrication, the forging bars must flow freely without tendency to rupture. Since switching to Carpenter, the forging shop has reduced rejections because of the cleaner, defect-free surfaces. The Carpenter representative near you can supply close metallurgical cooperation and complete technical data on your stainless requirements. The Carpenter Steel Company, 120 W. Bern Street, Reading, Pa.*

Carpenter STEEL

**The Carpenter Steel Company**

*Main Office and Mills, Reading, Pa.*
*Alloy Tube Division, Union, N. J.*
*Webb Wire Division, New Brunswick, N. J.*
*Carpenter Steel of New England, Inc., Bridgeport, Conn.*



Circle 514 on Page 19

The new Townsend Versa-Lockbolt* is an improved, yet more economical type. Design changes have increased the grip range of the fasteners and made it feasible to use them in relatively oversized holes. They are more economical to manufacture and the savings are passed on to you.

The high tensile pre-load values and positive locking action which have made lockbolted joints absolutely vibration-proof in the past are also provided by the Versa-Lockbolts. The new flanged integral washer-collars make Versa-Lockbolts especially suitable for fastening even light gage materials.

The wider grip ranges provided by additional locking grooves in the Versa-Lockbolt permit a reduction in the sizes stocked, reducing inventory costs and increasing production line flexibility. Installation inspection is reduced, since hole sizes are less critical. These savings, plus the lower cost of the fasteners made Versa-Lockbolts a truly economical method of vibration-proof fastening.

For full information, write Townsend Company, P. O. Box 237-E, New Brighton, Pa.

*Licensed under Huck patents RE 22,792; 2,114,493; 2,527,307; 2,531,048; 2,531,049 and 2,754,703

The Fastening Authority

**Townsend**

COMPANY • ESTABLISHED 1816

New Brighton, Pennsylvania

Sales Offices in Principal Cities

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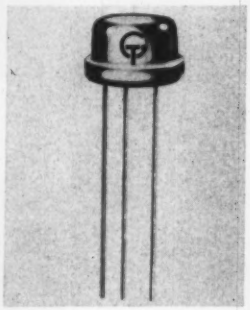
other products where air is to be heated while flowing through a tube or nozzle. Unit shown is for use in an electric hand dryer. Heating element is threaded through circular-shaped grooves on inside of a Steatite tube, providing for an unobstructed flow of air and high increase in heating efficiency. Low moisture absorption of tube reduces current leakage. Unit, which can be controlled thermostatically, is furnished in ratings from 500 to 2000 w at 115 v, and can also be furnished to operate on 220-v current. **Tuttle Electric Products Inc.**, Kirkland, Ill. J

*Circle 680 on Page 19*

## *Switching Transistors*

**are germanium units in PNP and NPN types**

Eight additional germanium alloyed junction switching transistors are available in both PNP and NPN types. PNP types are desig-



nated 2N311, 2N404, 2N426, 2N427, and 2N428; NPN types are 2N312, 2N439, and 2N440. All units are packaged in Jetec 30 cases. **General Transistor Corp.**, 91-27 138th Place, Jamaica 35, N. Y. D

*Circle 681 on Page 19*

## *Control Valve*

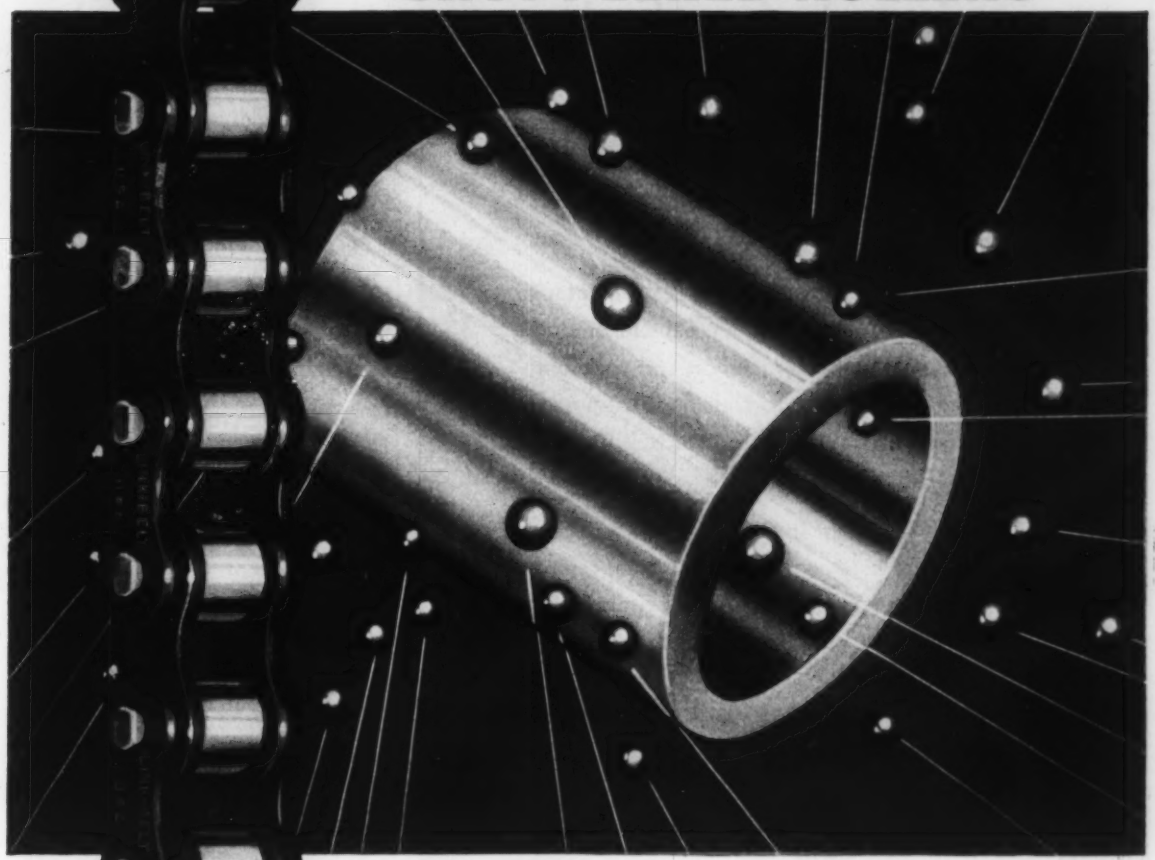
**has threaded exhaust ports**

Sliding-seal control valve has ¼-in. NPT ports and is available in two, three, and four-way types with levers for hand (left) and mechanical actuation (right). Equipped with threaded exhaust ports, valve is suited for operating single or double-acting cylinders with 3-in. diam bore. Flow capacity is 55 cfpm to accommodate larger cylinders. Exhaust air is piped to a

*Shining example of "extra" chain quality*

# SILVER-BRITE

## SHOT-PEENED ROLLERS



### EXTRA LIFE IS POUNDED IN AND NOT POLISHED OUT

Rollers for Link-Belt precision steel roller chain are now finished by a special burnishing process to a "Silver-Brite" luster! And this is accomplished *without grinding away the benefits imparted by shot-peening*—a Link-Belt process that cold works the metal and provides extra fatigue life.

Many more special Link-Belt "extras" contribute to the dynamic strength so important for today's heavy loads and high speeds: close heat-treat control . . . lock-type bushings . . . pitch hole preparation . . . pre-stressing.

Ask your Link-Belt office or authorized stock-carrying distributor for new 154-page Catalog 2657—the most complete roller chain data book ever compiled.

**LINK-BELT**

**ROLLER CHAINS & SPROCKETS**

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 14.978



Circle 516 on Page 19

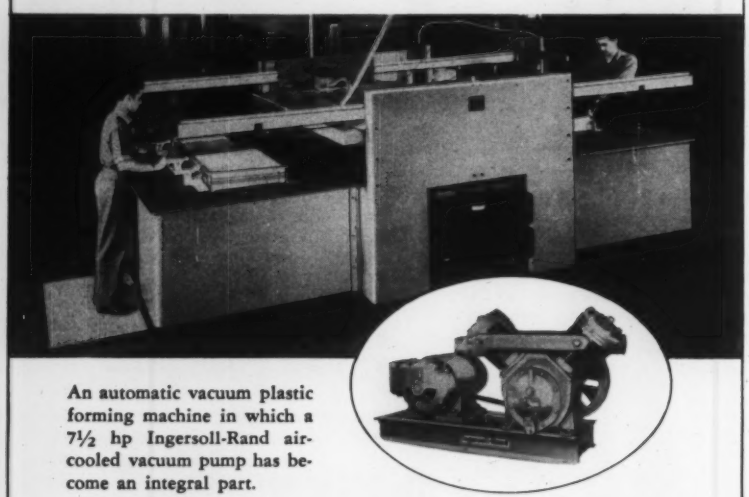
# "APPLICATION ENGINEERING"

## . . . is part of our business

If your problem is incorporating a compressed air or vacuum system in the machinery you are designing, Ingersoll-Rand can be of help.

Ingersoll-Rand, the world's largest manufacturer of compressors, has a complete line of small air-cooled compressors and vacuum pumps that range from ½ through 20 horsepower and are ideally suited for building into your product.

Why not call in an Ingersoll-Rand specialist, and let him help you with your compressed air or vacuum problem. Call your nearest I-R branch office or write for complete literature.

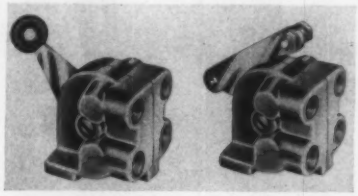


An automatic vacuum plastic forming machine in which a 7½ hp Ingersoll-Rand air-cooled vacuum pump has become an integral part.

**Ingersoll-Rand**

3-809 11 Broadway, New York 4, N.Y.



neutral point, eliminating air blasts and noises. **A. Schrader's Son, Div., Scovill Mfg. Co.**, 470 Vanderbilt Ave., Brooklyn, N. Y. C

*Circle 682 on Page 19*

### *Cap Screws and Nuts*

**have tensile strength of 186,820 psi**

Bowmalloy cap screws and nuts are produced from double heat-treated alloy steel. Screws have tensile strength of 186,820 psi, exceeding CAA bolt tensile-strength requirements. Screw also has new head design which has 20 per cent higher strength than SAE specifications, eliminating head damage caused by wrench slippage. **Bowman Products Co.**, 850 East 72nd St., Cleveland, Ohio. G

*Circle 683 on Page 19*

### *Subminiature Accelerometer*

**4-oz unit incorporates potentiometer pickoff**

Designated LA29-0100, subminiature accelerometer has a 1 in. diam and is less than 1½ in. long. It is suitable for precision inertial sensing in minimum space. Unit employs an integral weight and dry-gas damper combination. It is available in a variety of acceleration ranges and potentiometer characteristics to fit various requirements. The hermetically sealed, dry-gas-filled unit contains no plastic or other material affected by high temperatures. Temperature range is from −75 to 200 F, and satisfactory performance is obtained at

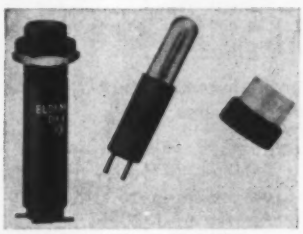
temperatures to 400 F. Accelerometer, which weighs approximately 4 oz, resists severe vibration and shock. Humphrey Inc., 2805 Canon St., San Diego 6, Calif. L

Circle 684 on Page 19

### Miniature Lamp Indicators

**replaceable units have current-limiting resistors**

1DH E-Lite replaceable lamp indicators are available with either neon or incandescent lamps, and incorporate current-limiting resistors. They are also furnished without resistors. Lenses may be plain or fluted, round or flat, wide or narrow, and come in several colors. Case diameter is ⅜ in., and case is



aluminum, black-anodized to MIL-A-8625 (ASG) for corrosion resistance. Lights are for use in computers, data-processing machines, automated control systems, instrument panels, and other electrical or electronic equipment requiring front-panel indication or readout. Eldema Corp., El Monte, Calif. L

Circle 685 on Page 19

### Motor Alternator

**two-bearing, 3600-rpm unit is rated at 1500 w**

Motor alternator, designed for a closely regulated 115-v, 60-cycle, single-phase output of 1500 w, with dc input to motor varying over a wide voltage range, is suitable for operation in extremely dusty locations. It is a two-bearing, 3600-rpm unit, totally enclosed and fan cooled, and includes inherent regulation. Both frequency and voltage of output are controlled within very narrow limits, regardless of wide variations in input voltage, load, and temperature. Output voltage is held within ±5 per cent of rated value, and frequency is held to ±2½ per cent. Unit is designed


Stearns MODEL GS
CLUTCH
NEW HIGH TORQUES —
SAME SMALL SIZES
Sets new standards of reliability and maintenance convenience

Min. Diameter 4½ in.
Max. Diameter 9¼ in.
Min. Depth - - 3½ in.
Max. Depth - - - 6 in.

NEW Torque Ranges —
Dry — 12 to 1260 lb ft; Wet (oil) — 16 to 1140 lb ft.
(former ratings from 9 to 540 lb ft.)

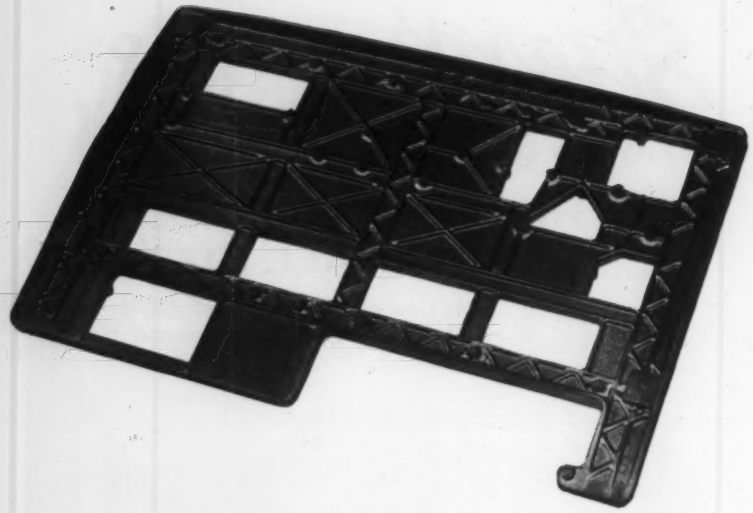
NEW Stearns Friction Discs —
provide long, trouble-free life — greater resistance to heat and pressure . . . seldom need adjustment for wear. Type "GS" friction discs can be replaced, or adjusted quickly and easily with just a screwdriver as your tool kit . . . for lowest-cost-per-year operation . . . specify Stearns!

✓ Check — Compare these additional $avings features:
- Stationary Magnet Body — simplifies installation. No thrust loads on shafts or machine elements. All clamping forces are self-contained.
- Plug-in Electrical Connections — No slip-rings, no brushes to install or maintain.
- Shipped Fully Assembled — you receive units from Stearns completely assembled, tested, ready for installation.
- Duplexed Bearings—conservatively loaded, sealed, prelubricated... assures longer, trouble-free life.
- Versatile Control — can be electrically energized by virtually any type switching device of adequate capacity.

Call your local Stearns Representative, or write direct for complete "GS" data.

Stearns ELECTRIC CORPORATION
120 NORTH BROADWAY
MILWAUKEE 2, WISCONSIN

Circle 518 on Page 19



# DUCTILITY

**A CASE IN POINT**—This ninety-six pound casting was made for the National Cash Register Co. of Nodulite®, Hamilton Foundry's ductile iron. The casting forms the base for the new Post-Tronic Accounting Machine. It measures 37½″ by 23½″ with sections varying from ¼″ to 1½″. Ductile iron was chosen for this part because of its ductility, dimensional stability, rigidity, and machinability.

Ductile iron has most of the engineering advantages of steel yet it can be designed with the same flexibility and cast with the same procedures used for gray iron. It has high strength: up to 120,000 psi minimum tensile strength in standard grades. It is tough: Charpy impact strengths up to 115 ft.-lbs. in standard grades. It is ductile: elongation is possible up to 25% after short time annealing. And it is wear resistant: spheroidal graphite particles provide for self-lubrication. Hamilton Foundry regularly casts 60-45-10, 80-60-03, 100-70-03, and 120-90-02 grades of ductile iron as well as high alloy Ductile Ni-Resist.

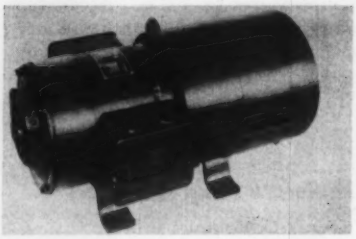
When new and unusual design problems arise in the selection of metal and the casting of parts, you will find that the skill and integrity of your foundry is your best insurance that specifications—and delivery schedules —will be met.

GRAY IRON • ALLOYED IRON • MEEHANITE® • DUCTILE (NODULAR) IRON • NI-RESIST • DUCTILE NI-RESIST • NI-HARD

# HAMILTON FOUNDRY

*The Hamilton Foundry & Machine Co., 1551 Lincoln Ave., Hamilton, Ohio • TW 5-7491*





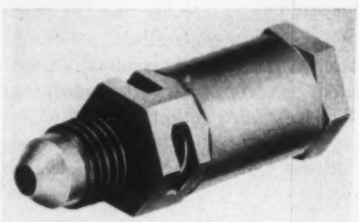
for applications on apparatus where dc only is available, and where a source of 115-v, single-phase, 60-cycle power is necessary to operate communications, television, or static-type control devices. Driving motors are supplied for nominal supply voltages of 250 or 120. **Safety Industries Inc.**, P. O. Box 904, New Haven, Conn. B

*Circle 686 on Page 19*

## *Relief Valve*

**for high temperatures and pressures**

Pressure-relief valve, which weighs only 0.04 lb (3/16-in. line size), handles pressures to 1000 psi at temperatures to 1800 F. Designed for rocket application, valve is used in gas-generator combustion chambers. It is adaptable to pressure-relief applications elsewhere in auxiliary power or main propulsion systems. **Aero Supply Mfg. Co.**, Corry, Pa. F

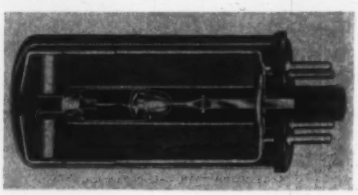


*Circle 687 on Page 19*

## *Mercury-Wetted Contact Relay*

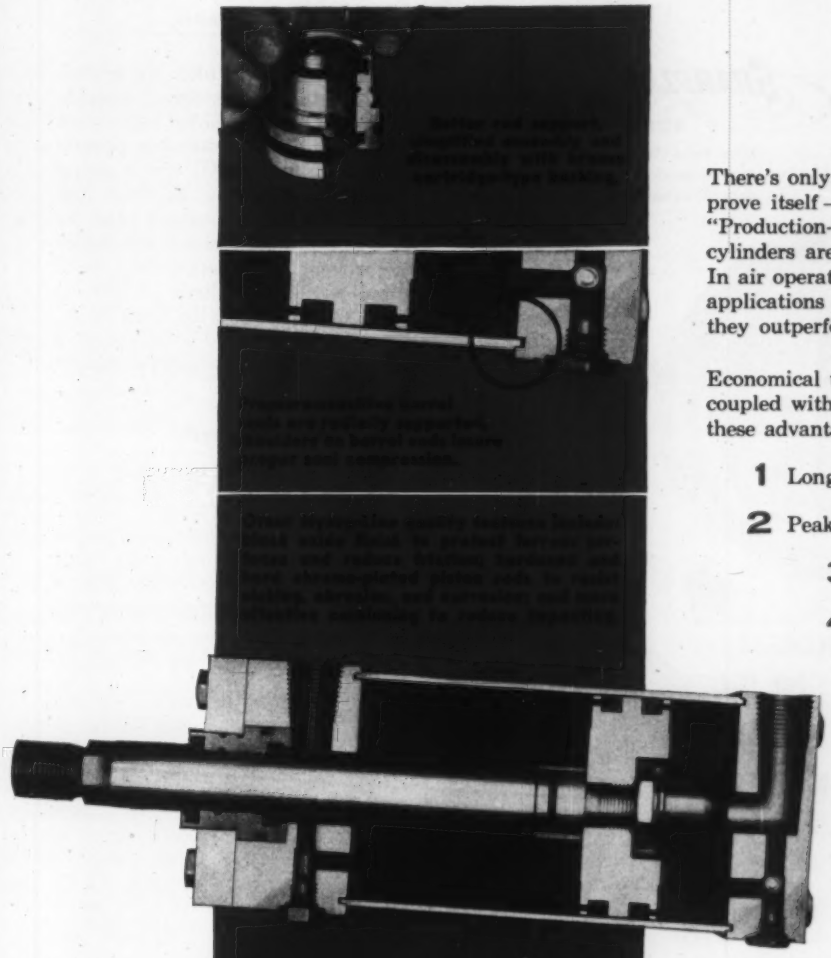
**for high-speed, sensitive switching devices**

Type HGS mercury-wetted contact relay is always biased with per-





*Circle 519 on Page 19*



# "production-proved" design pays off 4-WAYS

There's only one place for a cylinder to prove itself — on the job — and Hydro-Line's "Production-Proved" design Series R2 cylinders are doing just that.
In air operation up to 200 psi or hydraulic applications in the 500-2500 psi range, they outperform the best of the rest!

Economical use of quality materials coupled with sound basic design give you these advantages:

1. Long, trouble-free life.
2. Peak operating efficiency.
3. Low maintenance costs.
4. Simplified installation.

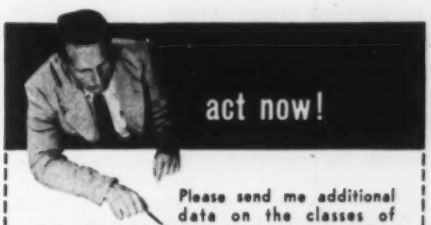
You get all these qualities in a complete line of standard cylinders. Cylinders for more than 90% of applications are available for immediate shipment from factory stocks, permitting minimum cylinder inventories without jeopardizing production. Also, even on small orders Hydro-Line offers discounts on stock "R2" and "N" cylinders.

Only a few of the advantages of the new Hydro-Line Series R2 are shown. But — you can get more facts by filling in the coupon below or contacting the Hydro-Line sales engineer near you. Ask to see the Series R2 demonstrator for a close-up look at a truly efficient design.

**HL HYDRO-LINE CYLINDERS**

**5602 PIKE ROAD • ROCKFORD, ILLINOIS**

manufacturers of: high- and low-pressure hydraulic cylinders • heavy-duty air cylinders • adjustable-stroke cylinders • dispensing cylinders • intensifiers • single-acting cylinders • booster cylinders




Please send me additional data on the classes of Hydro-Line cylinders checked below, including complete information on deliveries from factory stocks:

( ) Series R2 (heavy-duty air, medium-duty hydraulic, industry standard)
( ) Series N (heavy-duty hydraulic, industry standard)
( ) Series S2 (automotive industry automation standards)

Name and Title_____
Company_____
City_____ State_____

HYDRO-LINE MANUFACTURING COMPANY
5602 PIKE ROAD ROCKFORD, ILLINOIS



Circle 520 on Page 19

SHARPLES
SUPER-D-HYDRATOR

More than 400 of these centrifuges are now in service, with a combined daily capacity in excess of 1,600,000 cubic feet.

"Wear parts" made from KENNAMETAL help keep production high, downtime low

Against $(NH_4)_2SO_4$

# KENNAMETAL* components last 2 to 6 times longer...

**On Unloader Knives:** When processing corrosive Ammonium Sulfate (Coke Plant), the best life of any material tried for unloader knives on this crystal dehydrator was less than three months.† With Synthetic Ammonium Sulfate, the knives lasted little more than a month. By changing to knives made from Kennametal hard tungsten carbide, service life has been increased to twelve months or more with Coke Plant Sulfate, and up to four months with Synthetic Sulfate.

**On Distributor Tips:** With sulfates of either kind, Kennametal Distributor Tips in the feed assembly last up to eight months—double the life of any other alloys tried. Kennametal parts cost less in terms of longer life, increased production, and less downtime.

Chances are Kennametal can help *you* solve a problem involving corrosion, abrasion, erosion, or contamination. The Kennametal "family" of hard carbides includes grades three times as rigid as steel . . . grades that last up to 60 times as long as steel . . . grades that retain high strength at 2200°F and above or at subzero temperatures.

Let us tell you more about Kennametal and how it has helped others solve problems that may be similar to yours. Write to KENNAMETAL, INC., Dept. MD, Latrobe, Pennsylvania.

3128

*Trademark
†Based on an average daily throughput of 100-150 tons.

INDUSTRY AND KENNAMETAL ...Partners in Progress



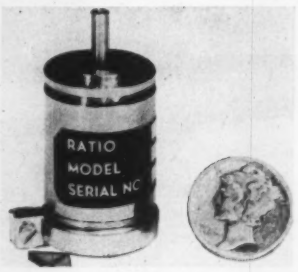

manent magnets which are adjustable for single-side stable or bistable operation. Designed for high-speed switching devices, unit has operating speeds up to 200 cps or more. Sensitivity is as low as ±2.5 mw for a bistable adjustment, and as low as 5 mw for a single-side-stable adjustment. Contact rating is 2 amp, 500 v, with limit of 100 va. **C. P. Clare & Co.**, 3101 Pratt Blvd., Chicago 45, Ill. I

*Circle 688 on Page 19*

## *Servomotor Gearhead*

**miniature unit adapts easily to Size 8 motor**

No. 760GH servomotor gearhead is a clamp-equipped miniature unit which adapts instantly to Size 8 motors. Double-lipped clamp imparts rigidity to over-all assembly and provides uniform clamping




pressure which will not cause warpage or other uneven strains. Internal post-type construction has been eliminated, which also serves to increase rigidity and improve vibration and shock resistance. Accuracy and permanency of component alignment are increased with new construction. **Bowmar Instrument Corp.**, 8000 Bluffton Rd., Ft. Wayne, Ind. J

## *Tantalum Capacitor*

**is shock and vibration resistant**

Type PP tantalum capacitor is for a wide range of electronic equipment requiring electrolytic capacitors with high capacity ratings and extremely small physical size. Anode base support provides excellent resistance to shock and vibration, qualifying unit for service under extreme environmental conditions. Capacitor is electrically stable in

# Wanted: Engineers

## *with an interest in writing*

Like to break into an interesting field where you'll make good use of your engineering talents — yet have a chance to develop new skills?

We're looking for several men with engineering experience and a yearning to write or edit. As an editor on MACHINE DESIGN, you would broaden your engineering background in a job that provides stimulating contact with people in many engineering areas.

You don't have to have actual writing or editing job experience, although we expect definite ability in handling the English language. An ME or EE degree plus several years of design-engineering experience would be ideal, but we'll be happy to consider equivalent qualifications.

If you've worked in a design-engineering specialty area, we'd like to hear about it. We're interested in any job experience or training in:

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- Mechanical components, assemblies
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- Hydraulic or pneumatic systems, drives, controls
- Materials and finishes selection or specification
- Design for manufacture or production design

Our headquarters are in Cleveland. There is opportunity for travel to engineering meetings, expositions, and manufacturing companies. Salary will depend on your background and experience.

If you are interested, send a resume of your engineering background, and any evidence you may have of writing ability (we'll return this if you wish) to: Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

MACHINE DESIGN

# BLOOD BROTHERS

## Universal Joints

**OFFERED BY ROCKWELL-STANDARD IN SIZES FOR ALMOST ANY PRODUCT APPLICATION**

## SAVE ENGINEERING TIME!

Here at Rockwell-Standard, you can select from a wide, wide range of Blood Brothers Universal Joints and complete drive assemblies. Torque capacities range from 350 to 500,000 inch-lbs.—lengths from very close-coupled industrial joints to assemblies 120 inches overall.

You can be confident they are produced in a modern, centrally located plant, tooled for precision manufacturing. And you can rely on their high reputation for dependability.

When you need universal joints and drive lines, you can save valuable engineering time too—by stating your problem to our engineers. They're cooperative, friendly and experienced. *Just write or call.*

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**ROCKWELL-STANDARD CORPORATION**

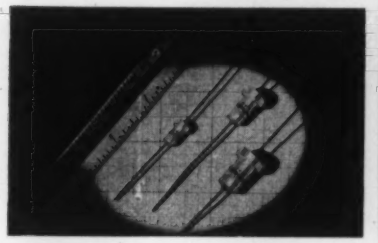
**Blood Brothers Universal Joints**

ALLEGAN, MICHIGAN

UNIVERSAL JOINTS
AND DRIVE LINE
ASSEMBLIES



Circle 524 on Page 19



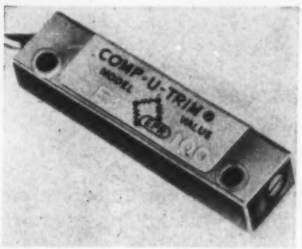
temperatures from −55 to 85 C, and exhibits excellent frequency stability and negligible electrical leakage. **Fansteel Metallurgical Corp.**, Dept. MDC, North Chicago, Ill. J

*Circle 689 on Page 19*

### *Trimming Potentiometer*

**has internally positioned wiper contact**

Comp-U-Trim Model E wire-wound linear trimming potentiometer features a completely encapsulated unit, zero end resistance, one-piece aluminum housing, positive end stops, large winding area, and internally positioned wiper contact. Designed to operate at 1 w at temperatures to 125 C, unit can be mounted singly or stacked. Measuring 5/16 x ¼ x 1¼ in., potentiom-




eter is available in standard resistance values from 10 to 30,000 ohms with temperature coefficient of 20 parts per million. **Eastern Precision Resistor Corp.**, 675 Barbey St., Brooklyn 7, N. Y. D

*Circle 690 on Page 19*

### *Gear-Case Oil Gages*

**screw-mounted units have plastic sight**

Screw-mounted gear-case oil gages permit instant check of oil level within transmissions or gear cases. Standard line includes five sizes with sight diameters from ¾ to 2 in. Plastic sight is available with permanent markings or graduations to suit individual applications. Sight

*Savings*

- Large 15 ampere contacts eliminate additional load relays.
- Stop down time with plug-in components for fast timer replacement.

*Flexibility*

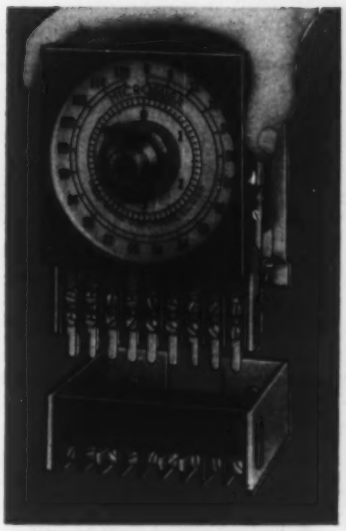
- Easy to set dial whether short or long timing.
- Choice of 9 actions available for each of 3 contacts. Select operation required for your circuit.

*Accuracy*

- Set dial to exact time required. No guessing at numbers.
- Accurate repeatability insures uniform production.

*Reliability*

- Proven reliability in thousands of industrial processes for more than 25 years.



Install timer in seconds with optional plug-in feature.

**EAGLE SIGNAL CORPORATION**
**Industrial Timers Division, Dept. MD-159**
**MOLINE, ILLINOIS**

Please send FREE Bulletin 110 containing complete data on Microflex Reset Timers.

NAME AND TITLE

COMPANY

ADDRESS

CITY ZONE STATE




*Circle 525 on Page 19*

# When the job calls for variable speed...

✓ You supply the problem—

✓ Lovejoy will furnish the solution

✓ ...saving you time and money in the bargain

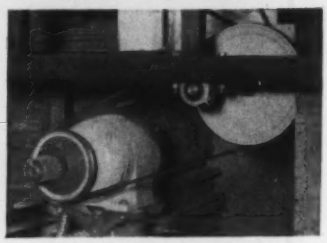
**Here's how...**

❶ Lovejoy sends you full information on the types of variable speed pulleys and transmissions available ... along with a guide sheet to help you supply us with pertinent information on the type you need and the service you require.

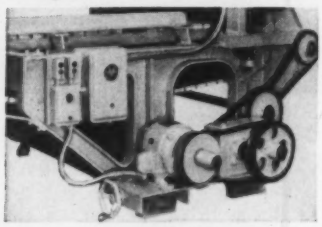
❷ Depending on your requirements, Lovejoy rushes recommendations, blue prints, suggested solutions to problems... or, if you desire, will send a representative to give you first-hand assistance. For standard or relatively simple applications, cost quotations can be furnished immediately.

- Speed ratios: up to 10 to 1
- Horsepowers: fractional to 15
- Constant belt alignment
- Instant speed changes while equipment is running
- Easily installed on new or old equipment.

**TYPICAL EXAMPLES:**

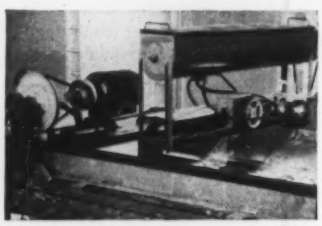


Type 160 Pulley and No. 200 Tilting Motor Base proved the right combination for a mailing machine.



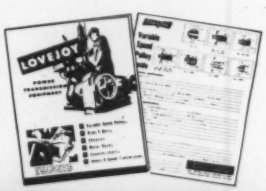
Proper drive for a slat bed rip saw is provided by a Type 302 Pulley.

Type 135 Pulley meets all requirements on a vibrating machine.



This Lovejoy "double" solved a grading machine problem — Type 145 Pulley and No. 2 Select-O-Speed.

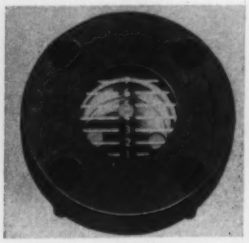
Put Lovejoy's exclusive individualized service to work for you: a complete line of variable speed pulleys and transmissions *plus* personalized engineering guidance to assure full satisfaction. Send for Catalog P58 and Form 118F today.




LOVEJOY FLEXIBLE COUPLING CO.

4818 W. LAKE ST. • CHICAGO 44, ILL.



is backed with cadmium-plated reflector which clearly reflects oil level, even in dim light. Mounting flange is fitted with oiltight gasket. **Gits Bros. Mfg. Co.**, 1866 S. Kilbourn Ave., Chicago 23, Ill. I

*Circle 691 on Page 19*

## *O-Ring Compound*

**for rings used with Skydol 500 and 7000**

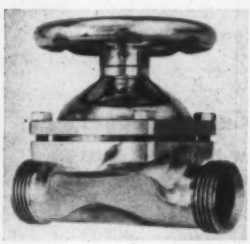
Compound 9078D has low compression set and resistance to swelling or deterioration. An extraordinarily tough material, it is for O-rings to be used with Skydol 500 and Skydol 7000. Compound also gives excellent service with any of the phosphate ester safety hydraulic fluids. **Precision Rubber Products Co.**, 3113 Oakridge Ave., Dayton 17, Ohio. G

*Circle 692 on Page 19*

## *Diaphragm Valves*

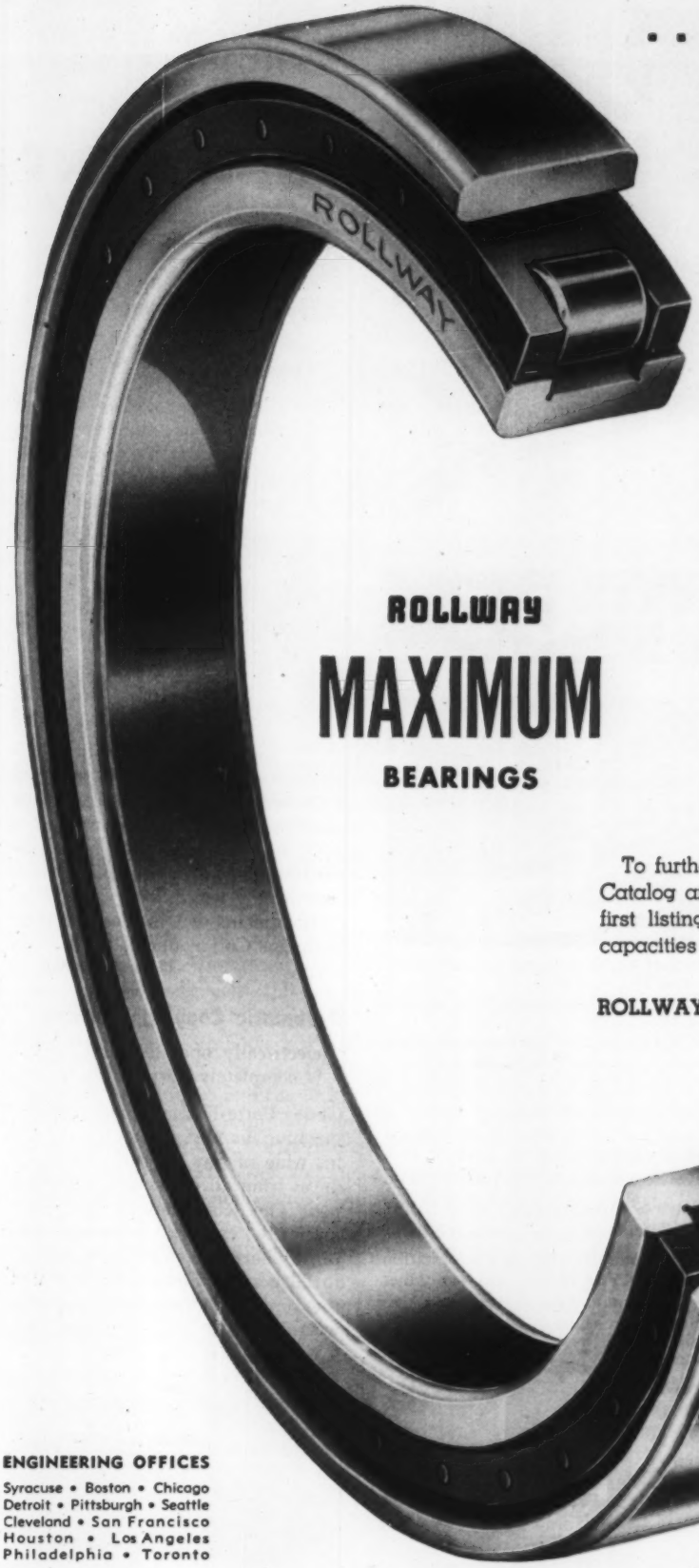
**are leakproof and corrosion resistant**

New valves permit maximum product flow within minimum of agitation, at temperatures to 210 F and pressures up to 150 psi. The leakproof, corrosion-resistant units are available in 1, 1½, and 2-in. OD tube sizes with sanitary threaded or



Tri-Clamp ends. All contact parts of the valves are Type 316 stainless steel. Valve has replaceable neoprene diaphragm. **Tri-Clover Div., Ladish Co.**, Kenosha, Wis. K

*Circle 693 on Page 19*




# . . . performance beyond the usual . . .

Design of high-speed precision machinery often calls for bearings which offer the utmost in load capacity, "hot hardness", dimensional stability. Each machine presents its own exacting requirements.

Fulfillment of unusual requirement combinations is a specialty at Rollway. Your selection of exactly the right precision radial cylindrical roller bearing is assured by:

- **A broad range of types and sizes, numbered in the thousands**
- **Retainers of standard bronze or "Rollube" ferrous alloy, in roller-riding, land-riding, or broached construction**
- **Crowned rollers**
- **Modification of any factor to meet your application**

**ROLLWAY**

# MAXIMUM

**BEARINGS**

To further implement your choice, the Rollway Catalog and Engineering Data Book contains the first listing, by any manufacturer, of the thrust capacities of cylindrical radial roller bearings.

**ROLLWAY BEARING CO., Inc., Syracuse 1, N. Y.**

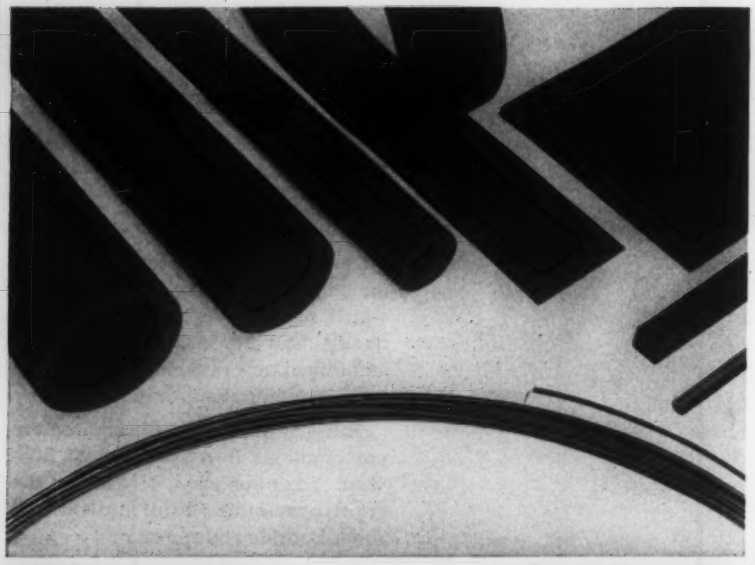
**ENGINEERING OFFICES**

Syracuse • Boston • Chicago
Detroit • Pittsburgh • Seattle
Cleveland • San Francisco
Houston • Los Angeles
Philadelphia • Toronto

**ROLLWAY**
Maximum
ROLLER BEARINGS



*Circle 527 on Page 19*



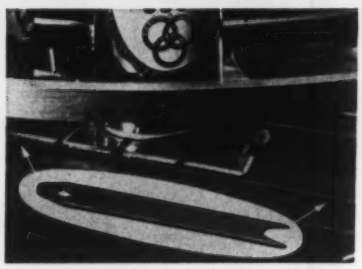
# NYLATRON® G S

## Gives the property advantages of nylon, PLUS . . . improved mechanical characteristics:

- Greater Rigidity—higher modulus of elasticity, less deformation under load.
- Higher Heat Distortion Temperatures—distortion temperatures 70% higher than nylon 101.
- Lower Thermal Expansion—coefficient approximately 60% of nylon 101.
- Low Surface Friction—can be used without lubrication.
- High Wear and Abrasion Resistance —can outlast, outperform metal.

NYLATRON GS, a molybdenum disulphide filled nylon*, is formulated to expand the field for nylon parts such as bearings, bushings, liners or other wear parts. Its superior mechanical and thermal characteristics coupled with the chemical and electrical properties of nylon result in a material with proven advantages. It is produced under controlled manufacturing standards to assure the ultimate in uniformity, quality and reliability.

Stock shapes of NYLATRON GS include rod, strip, tubing, tubular bar and plate in all standard sizes—for rapid, low-cost fabrication on standard metalworking tools. In addition, it is available in powder form for molding.



*NYLATRON GS wear strips provide excellent wear cushion between metal bottling chain and conveyor stands. Due to inherent wear resistance and low surface friction, NYLATRON outwears metal strip while reducing wear on chain and stand.*

Polymer can also supply stock shapes of all commercial nylons on request.

Write today for detailed information about NYLATRON GS—or other nylon formulations to meet your specific requirements.

*Patents applied for

**THE POLYMER CORPORATION OF PENNA.**
**Reading, Pennsylvania**
Export: POLYPENCO, INC., Reading, Pa., U.S.A.

POLYPENCO

POLYPENCO Nylon, POLYPENCO Teflon†, NYLAFLOW® and NYLATRON® GS †DU PONT TRADEMARK

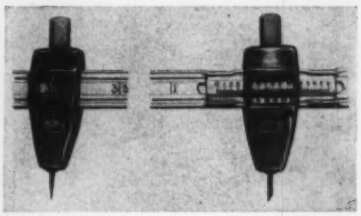

Circle 528 on Page 19

# ENGINEERING DEPARTMENT
# EQUIPMENT

## Caliper Beam Compass

**combines four tools in one unit**

Caliper beam compass can be used as a caliper, beam compass, scale, and divider. Dimensions can be set and marked to thousandths. Unit has an adjustable scale and



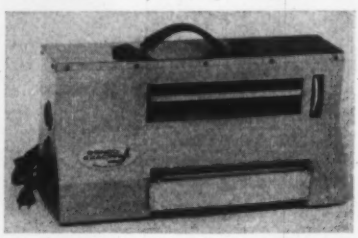
spring-loaded cursor to facilitate adjustment. Vernier scale is stamped into adjustable cursor. Anodized aluminum beam section is 9/32 x 9/16 in. Compass has metal inserts at all wear points, and is available in any length from 5 to 36 in. in increments of 1 in. **Ferance Construction Co.**, Penfield, N. Y. N

Circle 695 on Page 19

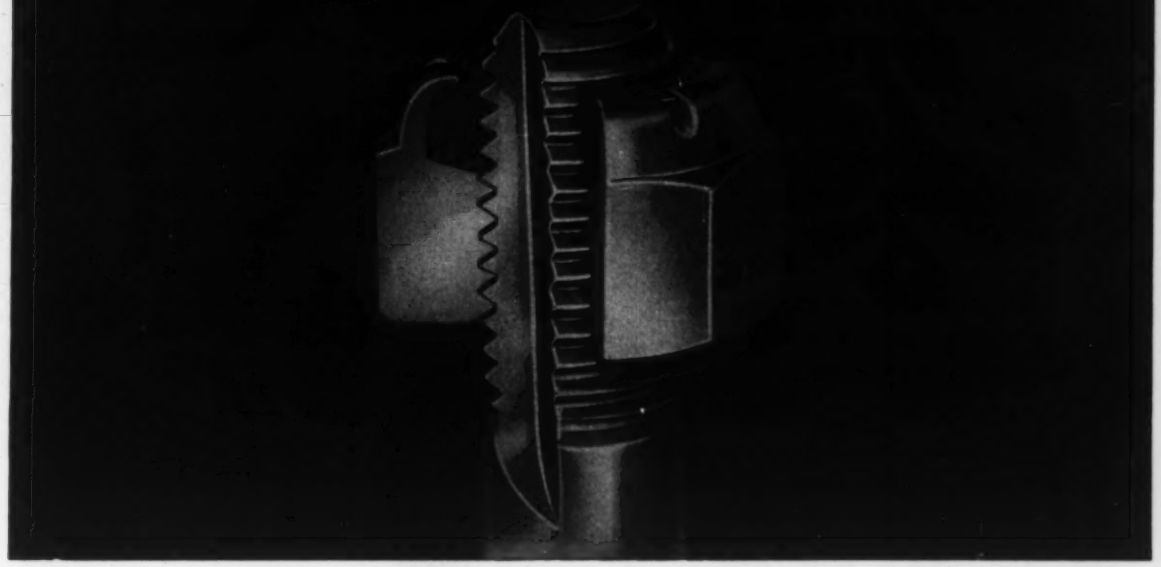
## Automatic Copying Machine

**electrically operated unit is completely portable**

Genco Porta-Fax automatic copying machine handles sheets up to 9½ in. wide of any length, and reproduces from all colors and ball-point pen. The self-contained unit automatically exposes, processes, and prints sharp copies at the rate of 60 to 90 per hr. Electrically operated, the unit is completely portable, weighing 18 lb and measuring 18 x 6 x 10 in. Machine operates on 115



# The nylon collared Elastic Stop nut never damages bolt threads!



## The nylon locking insert * will not seize threads, gall or remove plating

The red nylon locking collar is an integral part of an Elastic Stop nut. Undersize in diameter in relation to standard bolt tolerances, this insert grips the entering bolt threads with strong, smooth nylon fingers that dampen impact loads and resist turning under the most severe conditions of vibration or shock. The perfect fit between bolt threads and the locking collar also serves to seal off internal bolt and nut threads and to protect them against corrosion. Furthermore the nylon insert is impervious to gasolines, oils, salt atmospheres, cleaning compounds and common acids. The remarkable wear resistance of nylon plus its elastic recovery makes Elastic Stop nuts reusable through more than a hundred on and off cycles.

Because an Elastic Stop nut is a one-piece unit it is less expensive to install than castellated nuts and cotter pins, or double nuts. Equally important, it is a *stop* nut that *locks at any position on the bolt* without requiring secondary "safety" devices; it is simple to adjust precisely—it is easily wrenched off or readjusted. Elastic Stop nuts have been used by American industry since 1930 to solve the toughest applications on railroad, automotive, earth moving and farm equipment, as well as on all types of electrical machinery.

Elastic Stop nuts are available in sizes ranging from a watchmaker's 0-80 through 3", and in many standard finishes and materials including carbon and stainless steels, brass, duronze and aluminum.

**ELASTIC STOP NUT CORPORATION OF AMERICA**

*also maker of the* ROLLPIN TRADEMARK

*The Red Locking Collar is a Registered Trademark of ESNA

**Elastic Stop Nut Corporation of America**
**Dept. N27-14, 2330 Vauxhall Road, Union, N. J.**

Please send me the following free fastening information:

☐ ELASTIC STOP nut bulletin

☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name_____ Title_____

Company_____

Street_____

City_____ Zone____ State_____

# AVAILABLE FROM LOCAL STOCK

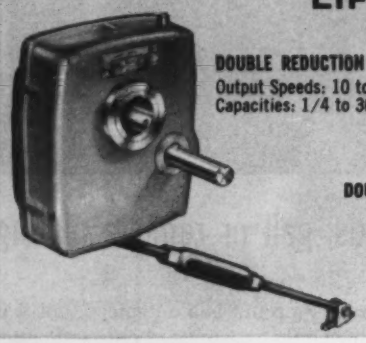
## FOOTE BROS. SHAFT MOUNTED DRIVES

WITH

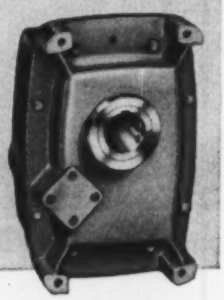
Duti-Rated®

LIFETIME GEARING*

**SINGLE REDUCTION**
Output Speeds: 90 to 420 RPM
Capacities: 1/4 to 40 HP



**DOUBLE REDUCTION**
Output Speeds: 10 to 160 RPM
Capacities: 1/4 to 30 HP

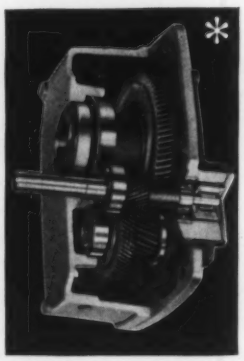


**DOUBLE REDUCTION FLANGE MOUNT**
Output Speeds: 10 to 135 RPM
Capacities: 1 to 7 HP

Foote Bros. Shaft Mounted Drives offer more efficient, more economical, power transmission. They incorporate exclusive **Duti-Rated** Lifetime Gearing — the high hardness, balanced design, premium quality gearing that combines greater load carrying capacity with long service life.

Used with standard V-Belts and Sheaves, Foote Bros. Shaft Mounted Drives will provide virtually any output speed you may require. Quick, easy installation on driven shafts with diameters from 15/16" to 3-7/16" saves time, labor . . . eliminates need for reducer mounting, couplings, and adjustable motor mount. Built-in Backstop to prevent reverse rotation, Automatic Overload Release Torque Arm, Variable Pulley, are available as optional equipment.

***The complete Foote Bros. Shaft Mounted Drive line is made in accordance with all applicable AGMA Standards***



***Write for NEW SHAFT MOUNTED DRIVE CATALOG***

100 YEARS SERVING INDUSTRY 1859-1959

FOOTE BROS.

*Better Power Transmission Through Better Gears*

FOOTE BROS. GEAR AND MACHINE CORPORATION
4567 SOUTH WESTERN BOULEVARD • CHICAGO 9, ILLINOIS




v ac under all normal light conditions, including fluorescent and incandescent lighting, or in daylight. Copies are clean-cut, opaque black on pure white, and two copies can be produced from one negative. Machine can be used for one or two-sided copies on single or duplex paper. **General Photo Products Co. Inc.**, General Photo Bldg., Chatham, N. J. D

*Circle 696 on Page 19*

### *Lettering Set*

**three guides have letters 1/8, 3/16, and 1/4 in. high**

No. 940 Hi-Lo letter set consists of three lettering guides, each containing both upper and lower case slant letters and numerals. Three sizes of letters are 1/8, 3/16, and 1/4 in. high. Designed to facilitate equal-spaced lettering, set is 0.030-in. double-cured, mathematical-quality plastic. Size of each template is 7 x 2 1/4 in. **Rapidesign Inc.**, P. O. Box 429, Burbank, Calif. L

*Circle 697 on Page 19*

### *Co-ordinate Drawing Machine*

**produces dimensionally accurate drawings**

Aristo Co-ordinatograph increases precision, neatness, and speed of drawing. Templates can be plotted readily, and measurements of existing drawings can be checked for conformity. Plotting mechanisms for $x$ and $y$ directions glide on ball bearings. Plotting precision is ± 0.0012 in. Drawing surface consists

of a glass plate with a translucent cover mounted on heavy, torsion-free frame, and can be leveled with adjusting screws of trestle legs. Table can be lighted electrically from below. Interchangeable drafting accessories are available. **Unitech Corp.**, 50 Colfax Ave., Clifton, N. J. D

*Circle 698 on Page 19*

## *Multicam Timer Kit*

**provides 96 time cycles from 40 sec to 18 hr**

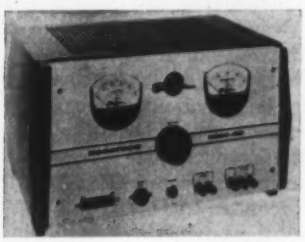
Basic construction kit provides all parts required for assembly of four multicam timers with 3, 6, 9, and 12 switches. Parts include four heavy-duty synchronous motors and 24 gear racks, providing 96 time cycles from 40 sec to 18 hr. Other parts are: 3, 6, 9, and 12-switch chassis; 30 switch assemblies, mounting brackets, and actuating levers; 30 adjustable cams; six etched blank cams; six main camshafts; tool kit. **Industrial Timer Corp.**, 1407 McCarter Highway, Newark 4, N. J. C

*Circle 699 on Page 19*

## *Power Supplies*

**unregulated units provide ac and dc outputs**

Variable-output, unregulated power supplies, designated RC-Nobatron Rangers, consist essentially of a variable autotransformer, rectifier, and



filter circuit. They provide both dc and ac outputs, and have low internal impedance as a result of conservatively rated components. Models are available to supply dc voltages from 0 to 36 and 0 to 150 v, each with 0 to 130 v ac. Either 36 or 150-v models are available in maximum dc power ratings of approximately 500 or 1000 w. **Sorensen & Co. Inc.**, Richards Avenue, South Norwalk, Conn. B

*Circle 700 on Page 19*

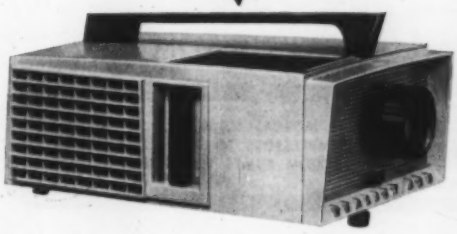
this lens magnifies sales

There's a mass-market price tag on this new Realist 620 color slide projector. Easy to see why: Realist used a low-cost aspheric lens by Lancaster—for a brighter sales picture.

Want lower unit costs for your product? Let Lancaster design the glass and plastic components.

design flexibility in glass

Lancaster
glass and plastics
to brighten your product's future



LANCASTER GLASS CORPORATION,
LANCASTER 2, OHIO

*Circle 531 on Page 19*

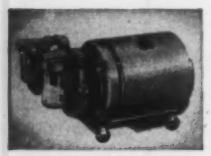
GAST

Model 3040 Oil-less Air Pump. Up to 20" vacuum, up to 10 p.s.i. pressure. Capacity to 24 c.f.m.

**Provide oil-free air blast with any of the carbon-vane**

# GAST rotary vane AIR PUMPS

Model 0240, 0440, 0740 Series Oil-less Air Pumps. Three displacements, from 1.9 to 5.6 c.f.m. Vac. to 15", pressure to 10 p.s.i.



Model 0211-P103-G8X Integral-Motor Oil-less. Up to 1.3 c.f.m. Motor 1/6 h.p. Wt. only 22 lbs. Smaller Model 0406 Oil-less has 1/12 h.p.

Need a pump that delivers absolutely *oil-free* compressed air? A Gast Oil-less Air Pump may be your answer! Built in seven different models — vacuum or pressure — these pumps* run *entirely without oil* in the pumping chamber.

Four carbon vanes lubricate themselves. Ball bearings are grease-sealed for life and separated from pumping chamber by a ventilated space. Air flow can't be contaminated with hot oil vapor.

You can *forget* oiling maintenance problems too! Simple construction delivers up to 15,000 hours' operation without attention, depending on r.p.m. and service conditions. This is a big advantage, especially when your product requires a compressor or vacuum pump mounted in a hard-to-service location.

Widely used on food-packaging, paper-handling, folding and laboratory machines.

**Write for full details — request Bulletins 152A and VP-356. GAST MANUFACTURING CORP., P.O. Box 117-P Benton Harbor, Michigan.**

*Standard oil-lubricated models also available.

SEE CATALOG IN SWEET'S PRODUCT DESIGN FILE

GAST ROTARY

- AIR MOTORS TO 7 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

"Air may be your answer!"

# Professional Viewpoints

## ...engineers and advertising...

*To the Editor:*

Design engineers and advertising men, although often at odds with each other, share an interdependence, solve their problems in much the same manner, and, professionally, are interested in the same things: A product, and the need for advertising and sales effort. These two commodities are, of course, interdependent. The engineer works from established fact and theory; the advertising man plans his advertising based on established market conditions and sales plans and uses established fact and theory in the field of communications to make his message effective. The engineer is interested in designing a better product than competition; the advertising man is interested in what makes the product better than competition, and why.

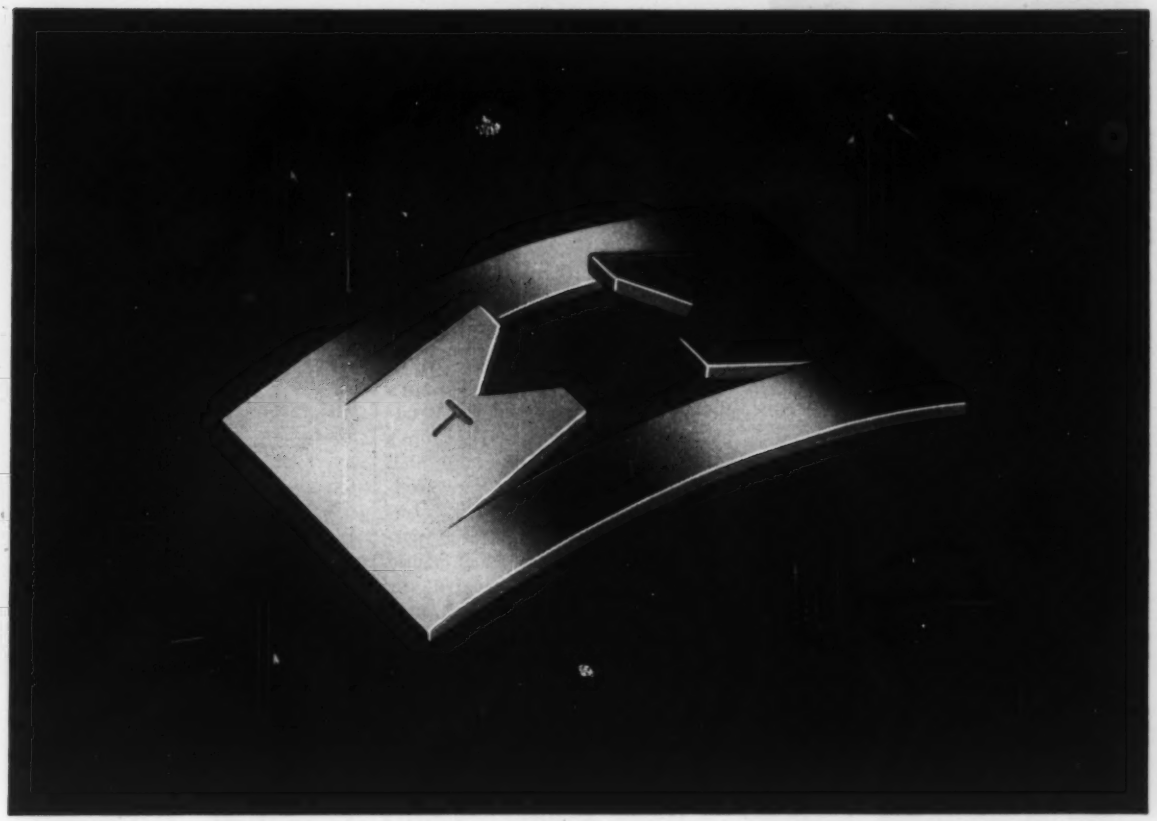
### The Design Engineer Can Improve Advertising

It's a fact that at least a portion of the advertising man's job is dependent upon information from the engineer who designed the product. The design engineer, however, works from information outside the knowledge and experience—if not the interest—of the ad man.

Thus, the design engineer becomes an important member of the advertising team. He is the creator of the product. He knows more about it than anyone else. And, the first requirement in advertising is: Know the product.

In supplying information to the advertising man (the "word" engineer), the design engineer finds a new responsibility—supplying facts which the advertising department can use effectively in promoting the sale of the product. Here are six ways the design engineer can help assure effective advertising:

**1. Include the advertising man in product-planning conferences.** Call him into planning conferences. Make him a working member of



*Another Tinnerman Original...*

# Tinnerman Push-On **SPEED NUTS®** fasten with a "bite" that can't shake loose

In a split-second, this low-cost Tinnerman Push-On SPEED NUT arches its spring-steel back, then bites hard to make a positive attachment on unthreaded studs, rivets, tubing, nails, jewels, small housings.

Application is easy—finger pressure starts it; a push with a simple hand tool locks it under live spring tension. No threads to worry about, no spot welding, no riveting, no special inserts, bushings or washers necessary. Elimination of extra parts and assembly operations may save you up to 50% or more in fastening costs.

Push-On SPEED NUTS lock on everything from thermoplastics to die-cast, chrome-plated steel. Hundreds of variations to fit any shape or size stud —from very small diameters to larger rectangular shapes. Some Push-Ons have "caps" that cover exposed shaft, axle or stud ends.

Check Sweet's Product Design File, section 8-T. Or look under "Fasteners" in the Yellow Pages and call your Tinnerman representative for complete information and samples. Or write to:

**TINNERMAN PRODUCTS, INC.**
Dept. 12 • P. O. Box 6688 • Cleveland 1, Ohio

**TINNERMAN**
*Speed Nuts®*

FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Hocaso-Bondy GmbH, Heidelberg.

put HEINZE in your designs

NEW... BLOWER-HEATERS

for warming and drying

Heinze new Blower-Heater Combination Units are ideal for warming and drying in such applications as hot food vending machines, photographic dryers, food warmers. Blower is designed for continuous operation. Heater can be thermostatically controlled through separate terminals.

Motor operates on 110 V, 60 cycles. Type DS delivers 55 cfm (free air) at 3000 rpm. Type YSS delivers 50 cfm (free air) at 1500 rpm. Heaters are available from 200 to 1000 watts, single phase. Coiled wire heating element is well insulated to protect outer wall. Choice of mountings includes outlet or inlet, flat strap, or "L" shaped brackets.

*Send coupon for complete technical data.*

HEINZE ELECTRIC COMPANY
685 Lawrence St., Lowell, Mass.
*Sub-Fractional Horsepower Motors and Blowers*

HEINZE ELECTRIC COMPANY
685 Lawrence Street, Lowell, Mass.

Please send me literature and price information on Heinze Blower-Heater Combination Units.

Name & Title.....

Company.....

Street & No.....

City & State.....

Circle 534 on Page 19



the team. Since he'll have to know the market, product, etc., before he can do an intelligent advertising job, get him "wrapped up" in the product during early product planning. Encourage him to contribute whenever possible. You may be surprised how much he knows about engineering, marketing, sales, manufacturing, and customer service problems. He's in continual contact with these groups and may have worthwhile contributions.

**2. Put yourself in the salesman's shoes.** While designing the product, put yourself in the salesman's shoes. Consider the problems he'll be faced with in selling your product against stiff competition. Improve the product wherever possible, within the bounds of sound engineering practice, to give the salesman and the advertising man substantial customer benefits to discuss in selling your product. A "customer benefit" headline in an advertisement, as compared with a "brag and boast" headline, will average close to 65 per cent better in "reader impact score."

**3. Tell the advertising man what's "newsy."** News information about the product, service, or company can be very rewarding in getting the sales story across to the reader. Advertisements using the "news" approach, generally, fare about 20 per cent better in getting the message across than all other advertising approaches. This is especially true when the news concerns a new product, or news about an established product. Your tips concerning product news may also lead to fruitful news releases, special features, or signed articles for trade publications.

**4. Tell him about the product.** To prepare advertising and sales promotion materials, the advertising man must first know just about everything you know concerning the product. Don't hold back any information no matter how insignificant you may consider it to be. It may turn out to be exactly what he needs. In any event, it is much easier to cut material than it is to stretch it, and your advertising man is trained in the art of sorting out facts. Here are some of the facts you can supply: What the prod-

Will your new products stand the sales test?

Many products using Monarch Exploratory-Engineered Castings are among the nation's sales leaders. Today's competitive markets demand new features.

This is another area where Monarch gives valuable assistance to customers. Monarch Exploratory-Engineering has created many sales-sparking casting performances and eye-catching finishes. Write today. We will be happy to show you specifics.

Engineered-for-sales aluminum permanent mold castings, aluminum and zinc die-castings.

MANUFACTURING ACHIEVEMENTS in MOLTEN ALUMINUM

MONARCH ALUMINUM MFG. COMPANY
9205 Detroit Avenue Cleveland 2, Ohio

Circle 535 on Page 19

uct is, what it does, and why it does it better. Give case histories, testimonials, test data, component information, etc. Explain how it works; how easy it is to operate, install, service and maintain; details of construction, operating characteristics, ratings, weights, dimensions, applications, etc.

**5. Tell him about competitive models.** Competition in industry is keen, and your advertising man can do a better job if you supply him with all the facts available to you concerning the competitor's product. If possible, chart the important features of the product for particular industries and compare your product with competitive designs in this framework.

**6. Be explicit in your statements concerning the product.** One of the biggest problems of advertising men is obtaining explicit facts which have punch when they're put in advertising materials. Most engineers qualify their statements to a point where they have little value. Give your advertising department, within the bounds of truth, every bit of ammunition that will help your company outsell competition.

The design engineer and the advertising man may seem to be strange companions, but their different talents can be combined with profitable results.

—William Allen Ternent
*General Electric Co.*
*Western Springs, Ill.*

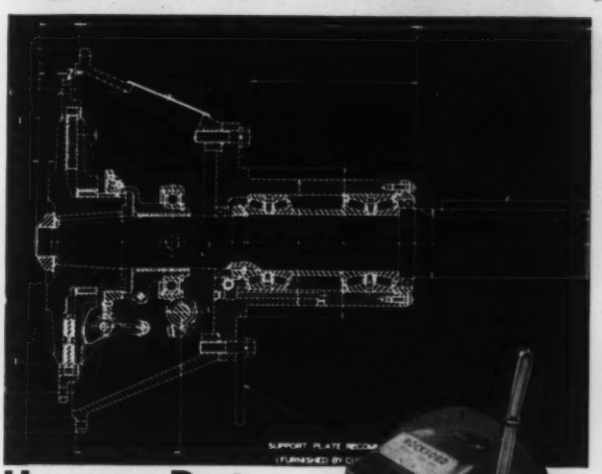
## ...optimum-strength fits...

Post-publication correspondence regarding the Data Sheet "Interference Fits" (Machine Design, October 30, 1958) included this bit of information from the author:

"It seems odd that the problem has not been mentioned previously in works of machine design, but I have not seen it nor have I met anyone who has. You might be interested in the odd way the problem came to my attention.

"My boys and I are building a steam engine for a wood-fired steamboat. We are building the engine from an Oldsmobile V-8 engine. The middle four cylinders, and that portion of the crankshaft, have the


ROCKFORD



Heavy-Duty
LONG LIFE

POWER
TAKE-OFF
Provides
THESE EXCLUSIVE ADVANTAGES

Designed to meet the needs of Oil Field and other rugged service—this ROCKFORD Extra Heavy-Duty POWER TAKE-OFF

- Eliminates the Pilot Bearing
- Release and Main Bearings are lubricated for one year
- Main Bearings are 40,000 hour type
- Handles 5,000 pound Belt Loads
- Out-Board Bearings and Flexible Couplings eliminated
- Furnished with Single or Double Plate, Organic or Morlife® faced Gear tooth Type Clutches

Insure longer work life and reduce down-time with this NEW extra heavy-duty ROCKFORD POWER TAKE-OFF.

SEND FOR THIS HANDY BULLETIN
Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

Small Spring Loaded

Automotive Spring Loaded

Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

Light Over Center

Power Take-Offs

Speed Reducers

ROCKFORD Clutch Division BORG-WARNER
311 Catherine St., Rockford, Ill., U.S.A.
Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

ROCKFORD B-W BORG-WARNER

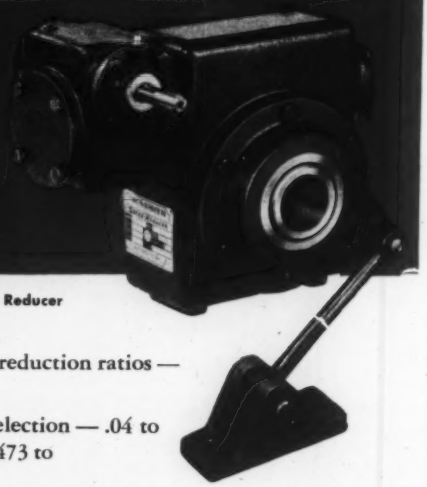
CLUTCHES




Circle 536 on Page 19

Model "SFD" Flange Mounted Reducer

NEW DOUBLE REDUCTION HOLLOW SHAFT worm gear speed reducers!



Model "STD" Torque Arm Reducer

- **THE COMPLETE** range of reduction ratios — 66⅔:1 to 4466:1.
- **THE COMPLETE** output selection — .04 to 2.55 HP. Torques from 1473 to 7678 in. lbs.
- **SHAFT-MOUNTED** ease of installation. Real space economy. No foundations required.
- **THE SAME RUGGED DURABILITY** and smooth, efficient operation for which Winsmith worm gear speed reducers have long been famous.
- **THIS COMPLETE** selection in choice of several assemblies.

**WRITE TODAY** for details on this new line which combines all the advantages of hollow shaft installation with worm gear, double reduction ratios engineered and precision-manufactured for you by Winsmith.

WINSMITH SPEED REDUCERS

**WINSMITH, INC.**
**16 Elton Street, Springville, (Erie County), N. Y.**




proper relations for a self-starting steam engine. The two cylinders on each end were sawed off with a hand hack saw. The crankshaft had its ends cut off. This made it necessary to put stubs in both ends of the crankshaft for the flywheel and drive and for the valve eccentrics. In discussing our plans it occurred to me that we should make a shrink fit of optimum strength for the stubs, and it was in this connection that I tried the problem.

"I hope you will not be let down by the article's humble beginnings."

—Frank R. Archibald
*Arthur D. Little Inc.*
*Cambridge, Mass.*

Editor's note: We're not, for its "humble beginnings" apparently did not detract from the article's usefulness. Over 800 requests for additional copies have been filled.—Ed.

## ...ideas...

*To the Editor:*

To the best of my knowledge, your article about adjustable fluid-flow from a fixed-stroke piston pump in "Scanning the Field For Ideas" (Machine Design, June 26, 1958) is certainly not a new idea; it was developed in Germany in 1924. Franz Lang of Munich, Germany, invented it and sold the patent to the Robert Bosch Co. of Stuttgart. This principle has been used in the Bosch injection pumps throughout the world for many years. Perhaps it is one of the few things the Russians have not claimed to have invented.

—James V. Brady
*St. Paul, Minn.*

Editor's note: This seems a good time to remind our readers of the purpose of "Scanning the Field for Ideas." This section was started in our first issue to present clever ideas that might have interest and value for readers in many branches of industry. The editors who write "Scanning" draw these ideas from many sources. In the case mentioned, Caterpillar did not contribute the material on the fixed-stroke piston pump.

The criterion is always potential usefulness across the entire design-engineering spectrum. While ideas adapted from specialized fields may not be brand new, the apparent age of this one should have disqualified it.—Ed.



Circle 537 on Page 19

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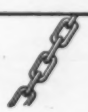
**Fasteners** **Hodell Chains**  **Chester Hoists**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## Recent Books

**Laminated Plastics.** *By D. J. Duffin; 254 pages, 5 by 7½ in., clothbound; published by Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y.; available from* MACHINE DESIGN; *$5.75 per copy postpaid.*

This book surveys the chemistry, properties, manufacturing methods, and applications of low and high-pressure laminates. Though not true laminates, vulcanized fiber and laminated films are also discussed.

**Marks' Mechanical Engineers' Handbook, Sixth Edition.** *Edited by Theodore Baumeister; 2270 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN; *$23.50 per copy postpaid.*

Retaining its past features of indexing and cross referencing, this edition has been modernized in all sections with no increase in over-all size of the completed volume. New additions or major changes are evidenced in such subject areas as computing machines, nuclear power, instruments, controls, aerodynamics, jet propulsion, and strength of materials.

Latest developments and thinking are also presented in sections on lubricants and lubrication, structural building design, welding, vibration, turbocompressors, gas turbines, displacement pumps, corrosion, pipe and fittings, aircraft propellers, automobiles, steam boilers, and railway engineering.

**A Compendium of Mathematics and Physics.** *By Dorothy S. Meyler and O. G. Sutton; 384 pages, 5½ by 8½ in., clothbound; published by and available from D. Van Nostrand Co. Inc., 120 Alexander St., Princeton, N. J.; $5.00 per copy.*

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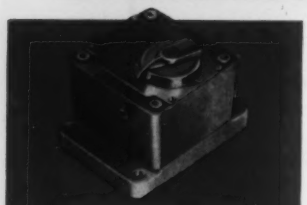

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briefly in each subject area. However, no proofs are given. Latest accepted values for basic physical constants are given only to the degree of accuracy required for routine laboratory work.

**Reliable Electrical Connections.** 286 *pages, 6 by 9 in., clothbound; published by and available from Engineering Publishers, GPO Box 1151, New York 1, N. Y.; $7.75 per copy.*

The 32 complete and illustrated papers presented at the third Electronic Industries Association 1958 conference cover various kinds of electrical connections used in electronic and power equipment. Fixed, disconnect, sliding, soldered, welded (including ultrasonic), pressure, and Wire-Wrap connections are discussed with relation to printed circuit and other applications, reliability, quality control, environmental evaluation, and specifications.

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**Wright Air Development Center Technical Reports.** *Each publication is 8¼ by 10¾ in., paperbound, and stapled; copies are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.*

The following report is available:

**PB 151145. Effect of Prior Creep on Mechanical Properties of Aircraft Structural Metals: Part 3—C110M Titanium Alloy.** *By J. V. Gluck, H. R. Voorhees, and J. W. Freeman; 96 pages; $2.25 per copy.*

**NASA Technical Series.** *Publications are 8 by 10½ in., paperbound; available from Division of Research Information, National Aeronautics and Space Administration, 1520 H St. N.W., Washington 25, D. C.*

The following reports are available:

**TN 4379. Torque-Speed Characteristics for High-Specific-Work Turbines.** *By Warner L. Stewart; 21 pages.*

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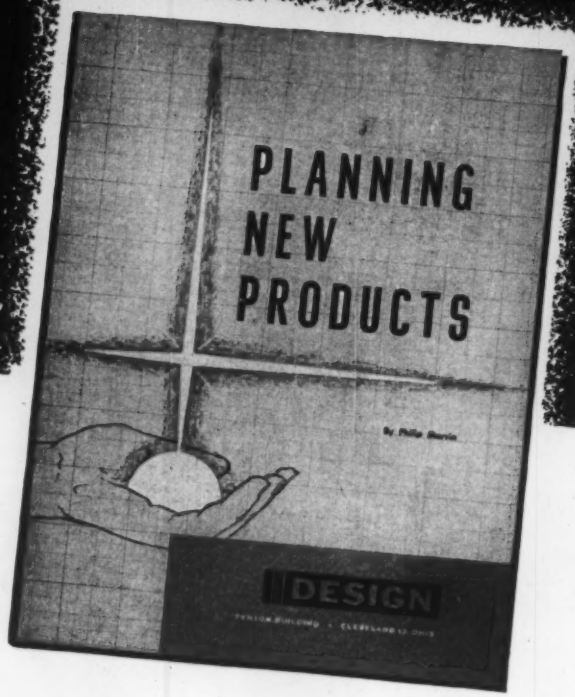


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# Patents

### *Angular-Displacement Control Device*

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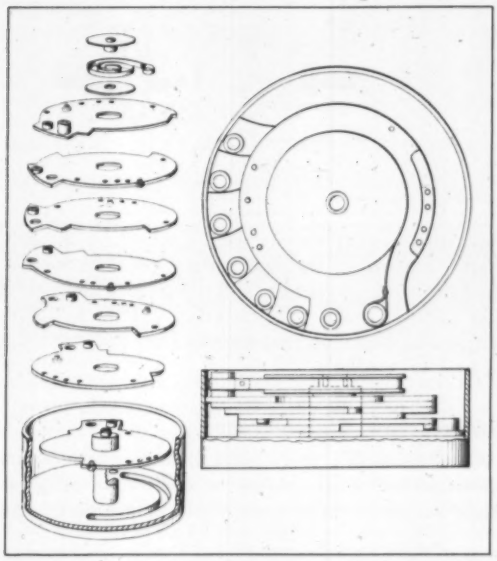

than 360 deg. Essential components of the device include a cup which encloses seven plate cams loaded by a torsion spring, all coaxial. The seven cams are identical in that all have the same outside shape, each has the same number and locations of peripheral through holes, and each has the same positions for the disc and body portions of an electrically fusible rivet. The cams are mounted on the cup shaft alternately upright and turned over. Under spring torsion, pins in the through holes limit relative displacement in pairs of adjacent cams to 64X, 32X, 16X, 8X, 4X, 2X, and 1X, respectively. Any displacement desired is the sum of two or more of these values. Displacements are fixed when electrical charges cause fusing of selected pairs. *Patent* 2,863,330 *assigned to the United States of America by John G. Moorhead.*

### *Wheel-and-Disc Friction Clutch*

Substantially no drag and no backlash are objectives for a friction-drive slip clutch intended for light-duty service. Located at the clutch-end of the driven shaft are a fixed triangular plate and a floating circular plate. Between these plates are three leaf springs each having opposite ends spot welded to the respective plates. When the clutch is at rest, the springs draw the plates


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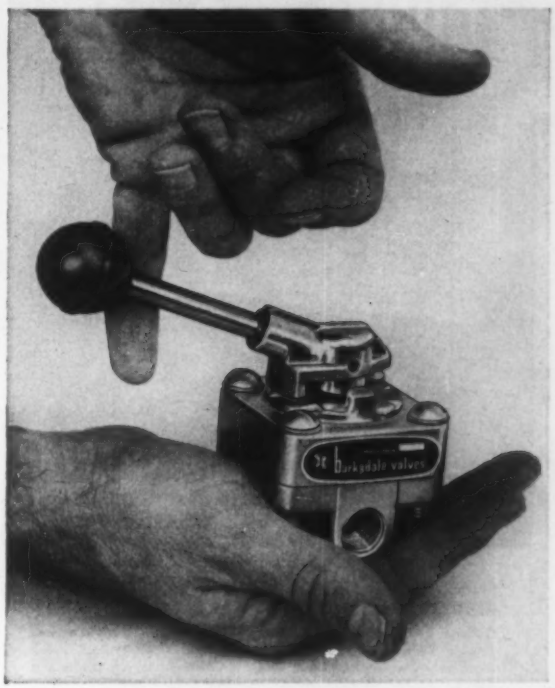

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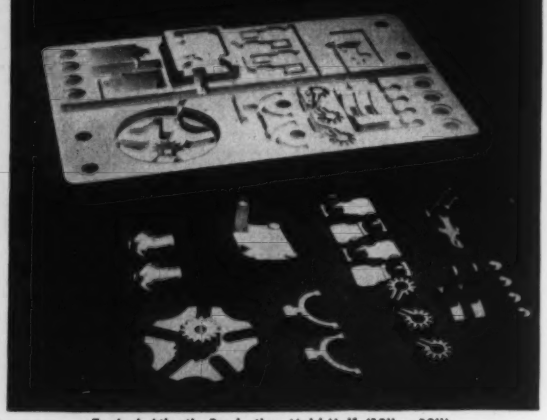

*Typical Atlantic Production Mold-Half (18" x 12")*

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together, out of contact with the driver, and spaced apart by a collar. The clutch is engaged by energizing two electromagnets which draw the edge of the round

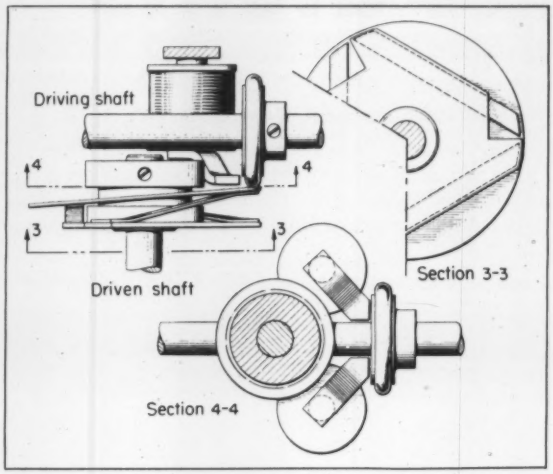
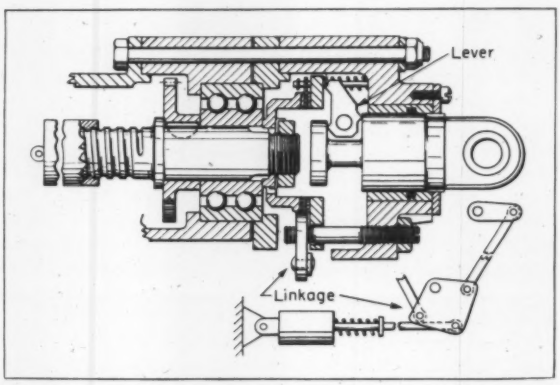



plate into friction contact with a wheel on the driving shaft. Flexure of the leaf springs provides nearly instantaneous engagement and their longitudinal stiffness assures negligible backlash. *Patent* 2,861,459 *assigned to Beckman Instruments Inc., Fullerton, Calif., by Erik W. Anthon.*

### *Power-Screw Clutch-Brake*

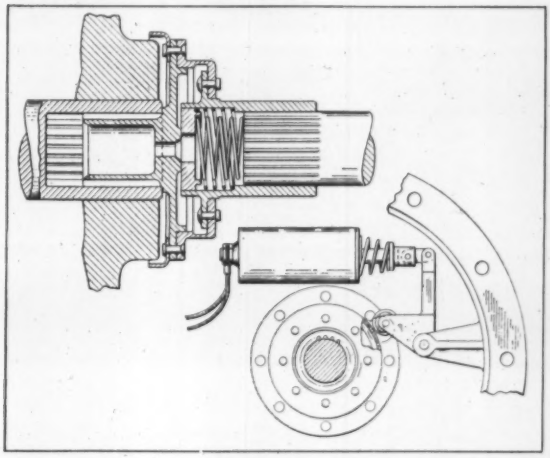
Cam action of a lever and a linkage enable a power-screw assembly to change or hold its configuration while loaded in either tension or compression. At one




end, a cylindrical member has a large eye, for connection to a fixed body, and an annular recess which receives a lever. Applied axial force causes the lever to cam about its pin and close a clutch fixed to the screw subassembly. Whether force is applied in tension or compression, the contour of the lever assures equal leverage, hence, equal braking force. To rotate the screw subassembly free of brake drag and with any amount of load, operation of a linkage causes threaded links to advance on studs. The links carry a clutch ring with them and thus separate friction sur-

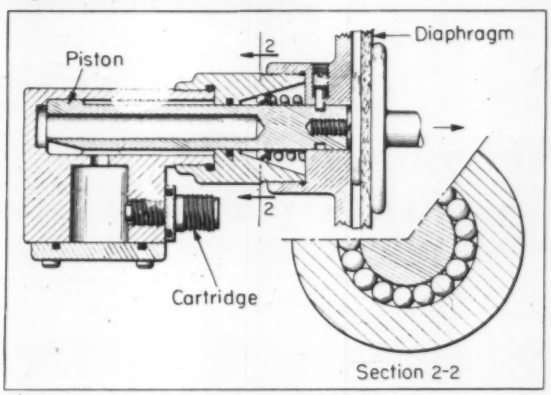
faces. This action is reversible. *Patent 2,857,775 assigned to Bendix Aviation Corp., Teterboro, N. J., by Leonard Ochtman.*

### Severable Shaft Coupling



When emergency conditions require the separation of driving and driven sides of a coupling assembly, a solenoid-actuated cutting tool severs the connection through the wall of a ring member designed weak for this very purpose. Severance requires a number of shaft revolutions, which is relatively slow rather than abrupt, to avoid shock and vibration in the tool and in the assemblies disengaged. The separation is maintained by two concentric helical springs which bear against the driven shaft and a floating disc. *Patent 2,862,375 assigned to Fairchild Engine and Airplane Corp., Bay Shore, N. Y., by Sherman B. Miller.*

### Explosive-Actuated Plunger




In an emergency actuator, high-pressure gas produced by the ignition of an explosive-filled cartridge causes rapid, linear motion of a counterbored piston and a coaxial rod on opposite sides of a flexible diaphragm. Under normal conditions, the rod is actuated by relatively low-pressure fluid applied to the diaphragm, and the piston is fixed axially by a threaded

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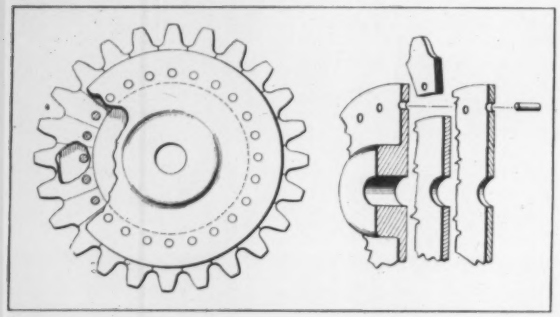
Circle 546 on Page 19

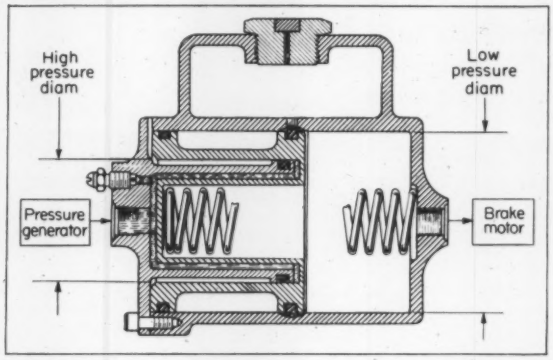
pin. In the emergency explosion, necessitated by pressure failure, the pin is sheared and the piston is held in any outer position it reaches by a ring of spring-loaded balls jammed into a conical wedge. *Patent 2,860,736 assigned to Talco Engineering Co., Hamden, Conn., by Jerome Belsky.*

### Built-Up Gear Assembly



Prefabricated components fastened with pins form a complete gear or sprocket assembly for heavy-duty service in which damage to teeth may occur. Teeth can be replaced individually by using simple hand tools. All other components are replaceable too. Thus, thick or thin hub members can be substituted on either side of the assembly, and different total numbers of teeth, can be installed. *Patent 2,862,399 assigned to Wald Industries Inc., Huntington, Pa., by John R. Wald Jr. and Rufus W. Wilson.*

### Differential-Pressure Piston Assembly




In a fluid-control mechanism which converts high pressure to low pressure, a floating piston of distinctive shape separates two incompatible working fluids in a way that neither contacts surfaces exposed at any time to the other. The high-pressure side is closed by a cap from which an integral cylinder projects. The floating piston, having an integral, concentric cup, telescopes the projecting cylinder and provides clearances for fluid flow. *Patent 2,849,865 assigned to B. F. Goodrich Co., by Burlin W. Oswalt.*

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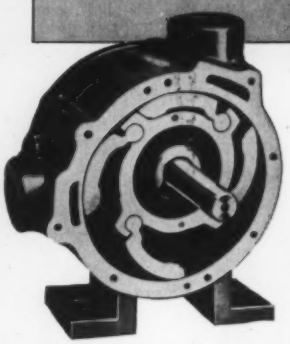

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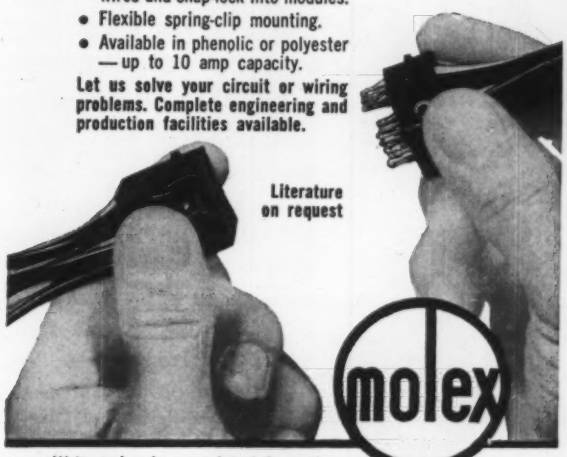


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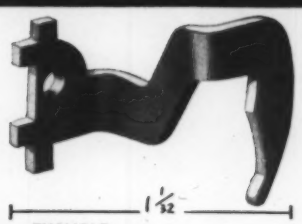


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| First 100 | $69.25 |
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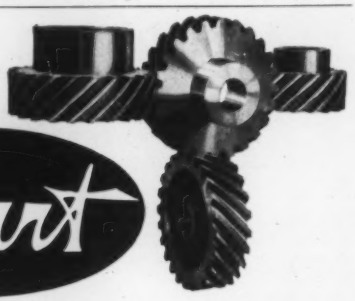

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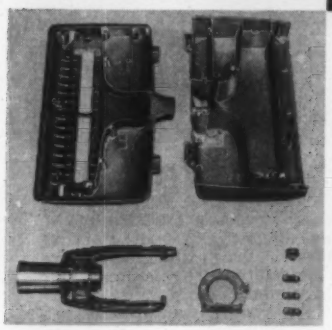

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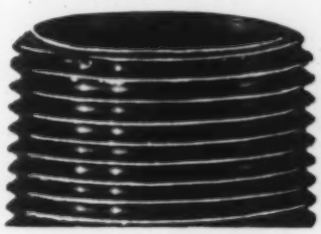

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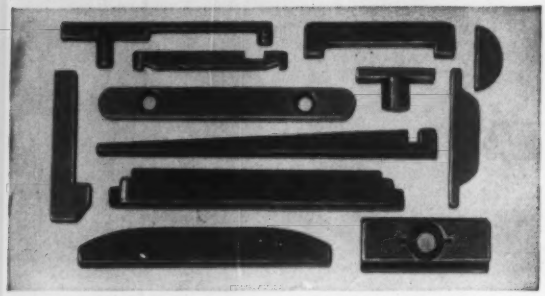

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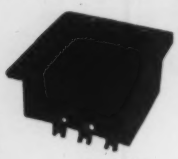

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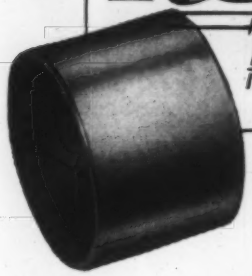

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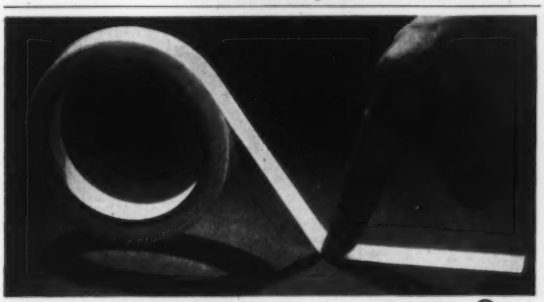

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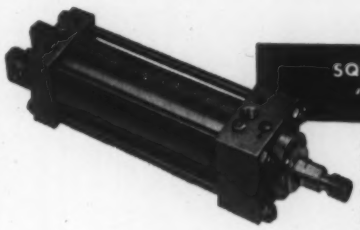

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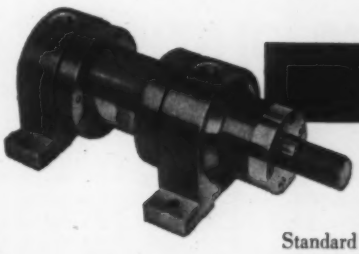

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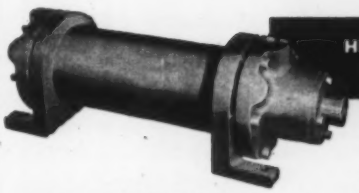

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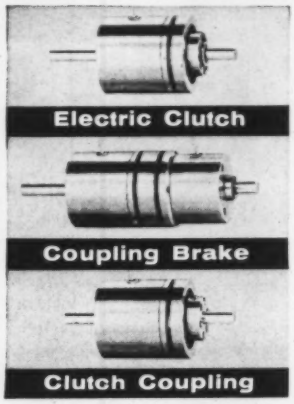


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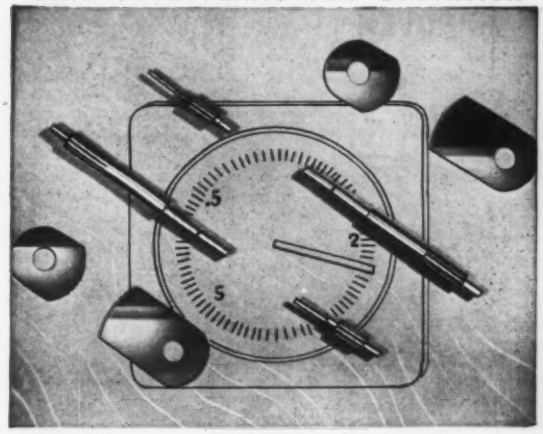

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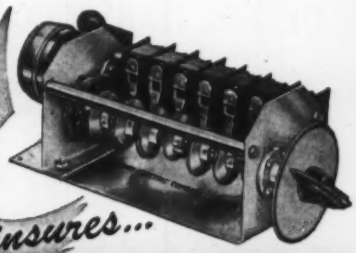

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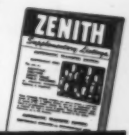


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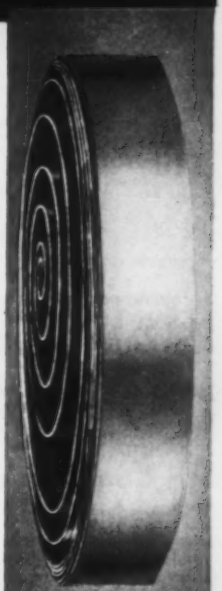

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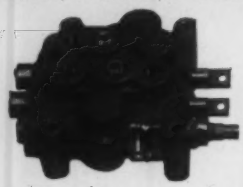

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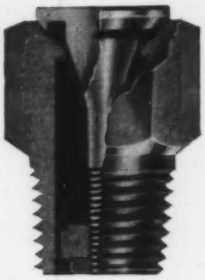

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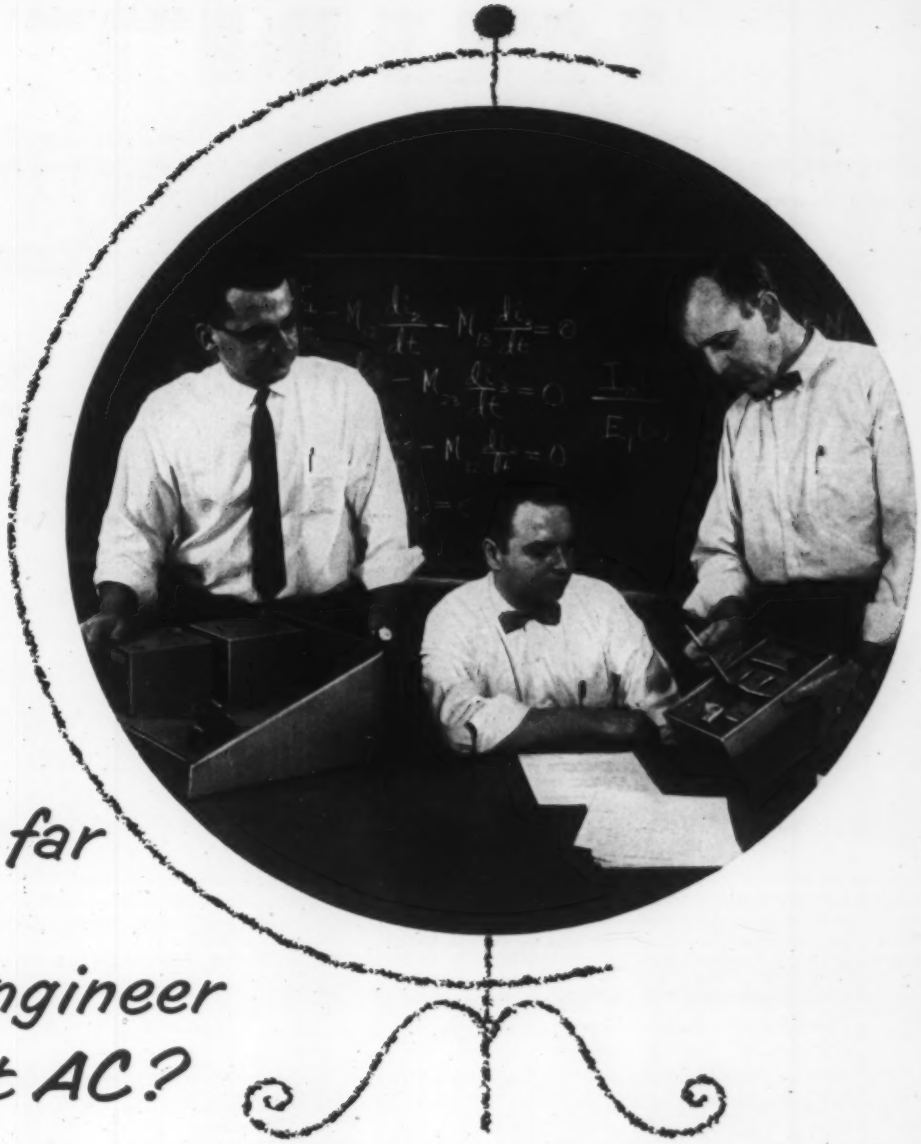

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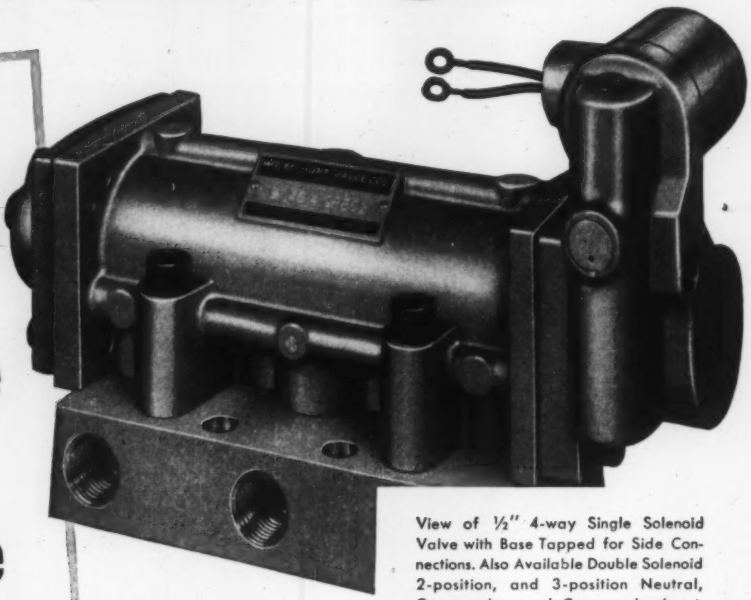

View of ½" 4-way Single Solenoid Valve with Base Tapped for Side Connections. Also Available Double Solenoid 2-position, and 3-position Neutral, Compound-on and Compound-exhaust.

### . . . in a completely comprehensive range of valve actions

**THE UNIVERSAL SIZE.** We asked O.E.M. buyers, large and small users; men out in the plant and plant managers,—"If you had to standardize on just one size of control valve, what size would you select?" Almost without exception they replied;—"½" size, it meets 85% or more of our requirements".

**UNTIL NOW** buyers have had to choose between a ⅜" valve tapped ½" but with **only ⅜" flow** (about 167 CFM); or, a ¾" valve tapped ½" but **selling at the ¾" price.**

**AGAIN HUNT LEADS.** Now, from Hunt, you can get a **full flow ½" valve** (257 CFM at 100 psig) in a complete range of actions, 2-way, 3-way, 4-way and 5-way, including single and double solenoid in AC or DC, any voltage, any cycle, explosion proof solenoid if desired; also hand lever, double pilot, pilot operated automatic return, and mechanically operated both directions, or with automatic return.

**GET FULL DETAILS NOW** about these new Hunt Valves that give you the flow you need, in the action you want, **at a ½" rather than ¾" price.**

**More startling HUNT designs to come!**

**Send for Bulletin No. 582-A TODAY!**

40 YEARS

# HUNT

**Quick-As-Wink®** AIR AND HYDRAULIC CONTROL **Valves**

**Manufactured by HUNT VALVE COMPANY, 2013 East Pershing St., Salem Ohio**

# buy your horsepower at the output shaft

Speed reducer problems involve more than just gear ratios. Horsepower, torque, overhung loads and duty cycle are considerations that require performance matching of motor and reducer. When you specify Master Gearmotors you eliminate dual responsibility for overall performance.

Master Gearmotors are packaged components, engineered to meet your requirements from line voltage to keyway dimensions. Motor and reducer are built as a single, rigidly aligned unit. These compact drives offer maximum efficiency and durability at minimum cost.

You can reduce engineering and assembly expenses by giving Master the responsibility for the entire power package. With Master Gearmotors you buy your horsepower where you need it, at the output shaft.

Vertical and horizontal, right angle and parallel shaft, worm, helical and herringbone gearing—⅛ thru 125 hp.

*Product of Master Electric Division of Reliance Electric and Engineering Company, manufacturers of a-c. motors, Reeves Drives, V★S Drives, Super 'T', D-c. Motors, generators, controls, and engineered drive systems.* E1609

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MASTER R REEVES

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# Name your bearing needs...we'll meet 'em pronto from 30 types, 10,247 sizes

TIME and time again, machinery makers come to the Timken Company for help with some special bearing application problem. One they think hasn't been solved before. And time after time, from our 30 types and 10,247 sizes of Timken® tapered roller bearings, we've come up with the bearing design to do the job and at minimum cost.

It's no accident that we can help out so often. In sixty years of helping machinery builders with bearing problems, we've engineered and produced the world's largest selection of tapered roller bearings. And we've constantly improved our designs. The answers to thousands of bearing application problems are already in our files. Ready and available to help you.

And machine users get the same swift service if they ever need a replacement Timken bearing. Even for old machines, they can almost always count on immediate delivery of Timken bearings for replacement.

Why not call on our engineers for help whenever you have a bearing application problem or requirement? Timken is your No. 1 bearing value. Wherever wheels and shafts turn, Timken bearings eliminate friction, cutting wear and maintenance to a minimum. Specify bearings trade-marked "Timken" for the machines you buy or build. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ont. Cable: "TIMROSCO".

*This symbol on a product means its bearings are the best.*

**TIMKEN** TRADE-MARK REG. U. S. PAT. OFF.

*TAPERED ROLLER BEARINGS ROLL THE LOAD*

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